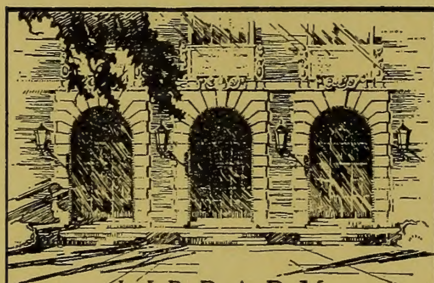

Physics

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QUARTERLY TECHNICAL PROGRESS REPORT

July, August, September 1967

DEPARTMENT OF COMPUTER SCIENCE · UNIVERSITY OF ILLINOIS · URBANA, ILLINOIS

QUARTERLY TECHNICAL PROGRESS REPORT

July, August, September 1967

Department of Computer Science
University of Illinois
Urbana, Illinois 61801

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1. CIRCUIT RESEARCH PROGRAM

(Supported in part by the Office of Naval Research under Contract N00014-67-A-0305-0007).

Summary

Larry Ryan describes the photomultiplier detection circuit that is used in the PARAMATRIX slide scanner.

In the area of Random Sequence Coding, Chushin Afuso presents an error analysis for various arithmetic operations, and John Esch outlines the properties and a computer application of a general stochastic computing element.

The Geomatrix II project has been renamed Potentiomatrix. Bill Steiner considers the problems involved in approximating an infinite, continuous resistive sheet by a finite, discrete resistor grid.

Finally, Larry Wallman describes some "tidying up" operations on the working model of Phastor.

1.1 PARAMATRIX (Project No.01)

1.1.1 General

During this quarter the final circuits for the PARAMATRIX slide scanner were designed and checked out. A bread board version of the entire scanner system has been constructed and is operating well. By adjustment of the horizontal and vertical sensitivity controls, the slide input pattern can be displayed and manipulated on the output matrix with a minimum of flicker.

1.1.2 Photomultiplier Detection Circuit

It was mentioned in earlier reports that a photomultiplier tube is used to detect the presence of light behind the input slide. A schematic of the circuit that amplifies and shapes the output of the photomultiplier is shown in Figure 1.

Transistors T_1 and T_2 serve to amplify the input signal by a factor of 3 and tend to isolate the base of T_3 from spurious low level input signals generated by small amounts of ambient light. The .47μf capacitor across the 1k resistor holds the emitter of T_3 fixed at -.8 volt as far as pulses are concerned. The collector of T_3 is normally at about 1 volt.

A negative pulse at the base of T_3 cuts the transistor off and the collector rises to 10 volts. Transistor T_3 is quite sensitive, and any noise that appears at the base of T_3 causes small positive pulses to be present at the collector. For this reason diode D_1 and the 10k potentiometer are used to form an amplitude-discriminating circuit for the pulses at the collector of T_3. The wiper arm of the potentiometer is set to approximately 5 volts, thus rejecting all small positive pulses that appear at the collector of T_3. The 6.2 volt Zener diode level-shifts the pulses which exceed 5 volts to provide for proper triggering of the flipflop.

The memory is a standard flipflop with catching diodes to form a compatible logical output. A positive trigger at the base of T_4 turns the transistor off, and the output signal to PARAMATRIX goes to -5 volts.

The clock input is differentiated by the high-pass RC circuit, and the negative peaks are clipped off by diode D_2. Thus, only the positive triggers reach the base of T_5, resetting the flipflop at the beginning of every clock cycle.

L. Ryan

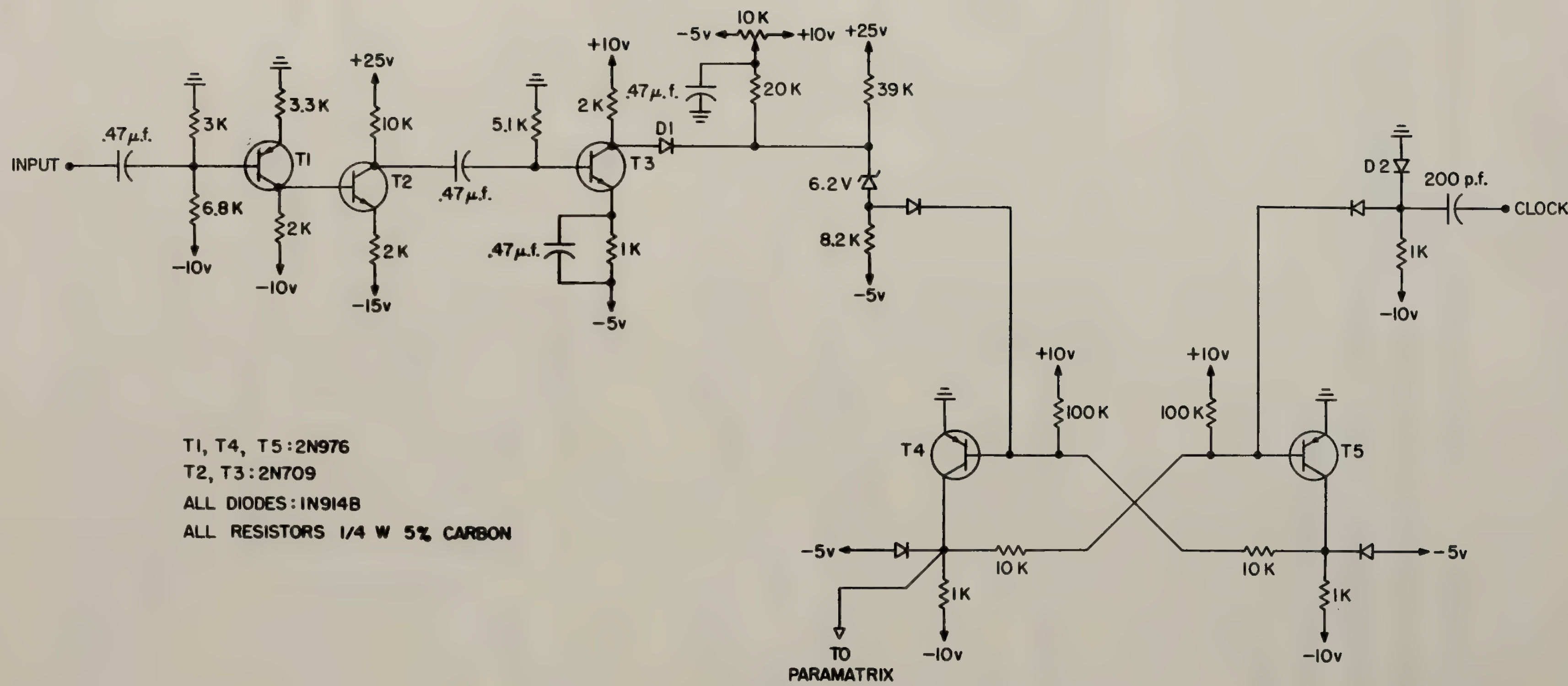


Figure 1. Photomultiplier Detection Circuit.

1.2 Random Sequence Coding (Project No. 03)

1.2.1 Estimate of Accuracy of the Adder

The schematic diagram of the adder is shown in Figure 1. The coincident pulses are temporarily stored in the counter. When blanks are found at the output of the OR gate, stored pulses are inserted one by one. At the same time the contents of the counter are cleared.

The accuracy naturally depends on the size of the counter. To estimate the accuracy, a binomial distribution is assumed for the pulse distribution of the SRPS's.

The accuracy of an adder which has a counter of capacity k pulses will be found. This adder will, for the sake of convenience, be called "a kth order compensated adder." A 'range element' is defined so as to facilitate the calculation. This element has (n+1) clock cycles starting at the first coincidence and ends at the cycle preceding the (k+1)th coincidence, as shown in Figure 2. For kth order compensation to be effective, it is necessary (but not sufficient!) that the first blank occurs before the (k+1)th coincidence in each range element. In reality, the counter of capacity k pulses is not able to accept k pulses in every range element, since there are pulses in the counter which have been carried over from the preceding range element. This storage action considerably complicates a detailed analysis. Since the primary purpose here is an estimate of the accuracy, the assumption will be made that the counter is always able to accept k pulses and thus a rough estimate for design purposes will be obtained.

P { kth order compensation is effective for a given range element of (n+1) cycles } = P {(k+1)th coincidence occurs at (n+1)th cycle and at least one blank occurs before (n+1)th cycle for the ORed sequence} = P {(k+1)th coincidence occurs at (n+1)th cycle}·P {At least one blank occurs before (n+1)th cycle, assuming that (k+1)th coincidence occurs at (n+1)th cycle} (1)

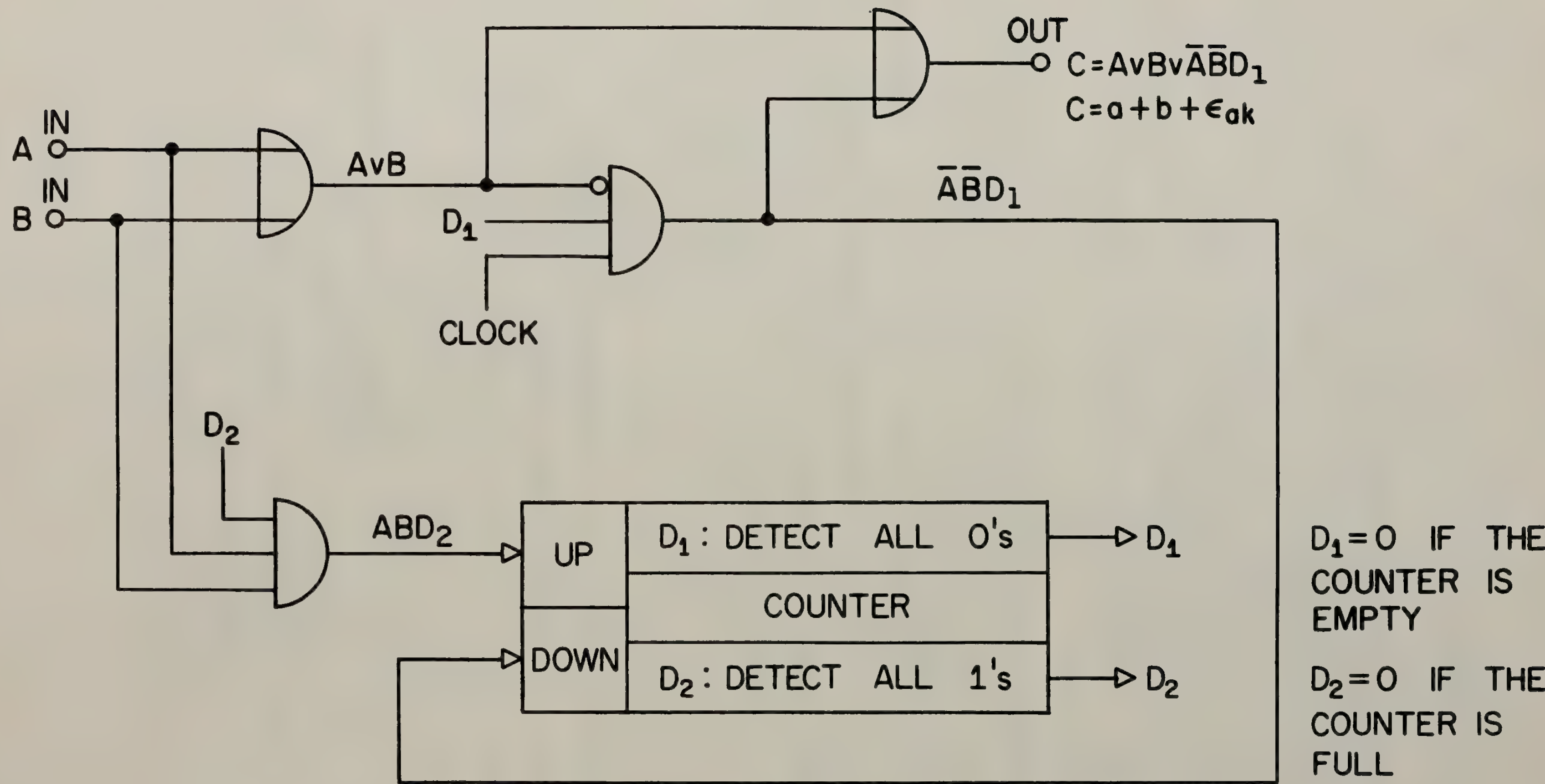


Figure 1. Addition: $c \simeq a + b$.

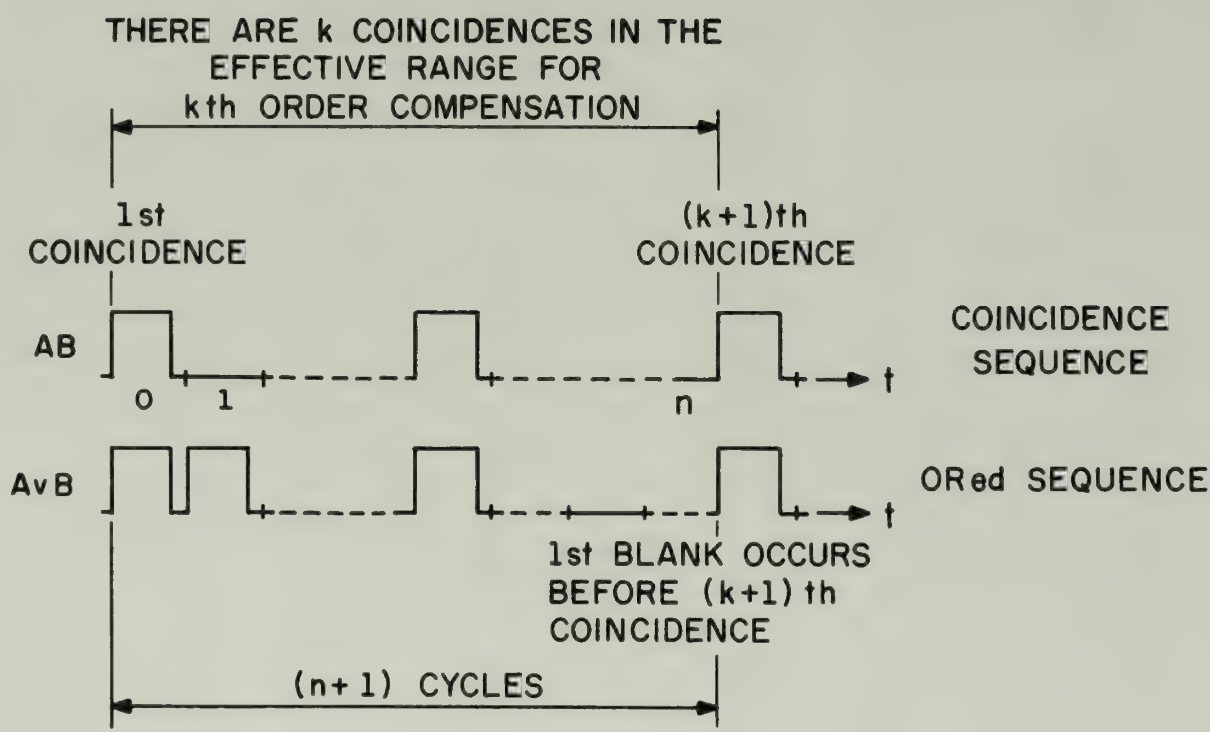


Figure 2. Illustration of Pulse Sequences Showing the Principle of Analysis of kth Compensation for Addition.

Paying attention to the coincidence sequence,

P {(k+1)th coincidence occurs at (n+1)th cycle}

$$= \binom{n}{k-1}(ab)^{k-1}(1-ab)^{n-k+1}(ab), \qquad k-1 \leq n \qquad (2)$$

To make the analysis simple, we assume that the second conditional probability is independent of the first part in (1). Although this is not strictly true (because the coincidence sequence is not independent of the ORed sequence), it would seem permissible for our present purposes. Hence, the second part of (1) reads:

P {At least one blank occurs before (n+1)th cycle}

$$= 1 - (a + b - ab)^n \qquad (3)$$

Hence, from (1), (2) and (3),

P {kth order compensation is effective for a coincidence pulse} $= \sum_{n=k}^{\infty}$ P {kth order compensation is effective for a given range element of (n+1) cycles} $= \sum_{n=k}^{\infty} \binom{n}{k-1}(ab)^k$

$$(1-ab)^{n-k+1}\,[1-(a+b-ab)^n] \qquad (4)$$

$$= \frac{(ab)^k}{(k-1)!}\Big[\sum_{n=k-1}^{\infty} n(n-1)\ldots(n-k+2)\quad(1-ab)^{n-k+1}\,\{1-(a+b-ab)^n\}$$

$$-(k-1)!\ \{1-(a+b-ab)^{k-1}\}\Big]$$

$$= \frac{(ab)^k}{(k-1)!}\Big[\sum_{r=0}^{\infty}(r+k-1)(r+k-2)\ldots(r+1)(1-ab)^r\ \{1-(a+b-ab)^{r+k-1}\}$$

$$-(k-1)!\ \{1-(a+b-ab)^{k-1}\}\ ]$$

provided $k \geq 2$.

Now it can be shown that

$$\sum_{r=0}^{\infty} (r+k-1)(r+k-2)\ldots(r+1)a^r = \frac{(k-1)!}{(1-a)^k},\ k \geq 2,\quad |a| < 1$$

Hence,

P {kth order compensation is effective for a coincident pulse}

$$= 1 - \frac{1}{a+b-ab}\left[\frac{ab(a+b-ab)}{1-(1-ab)(a+b-ab)}\right]^k - (ab)^k[1-(a+b-ab)^{k-1}] \quad (5)$$

and the amount of compensation is

$$ab - \frac{ab}{a+b-ab}\left[\frac{ab(a+b-ab)}{1-(1-ab)(a+b-ab)}\right]^k - (ab)^{k+1}[1-(a+b-ab)^{k-1}] \quad (6)$$

Although $k \geq 2$ was assumed in the course of derivation of (6), this is also valid for $k = 1$. A proof can be carried out easily by substituting $k = 1$ in (4).

The second and the third terms of (6) represent the error, and therefore the error ε_{ak} with respect to the full range of the machine variable value, 1, is

$$\varepsilon_{ak} = -\frac{ab}{a+b-ab}\left[\frac{ab(a+b-ab)}{1-(1-ab)(a+b-ab)}\right]^k - (ab)^{k+1}[1-(a+b-ab)^{k-1}],$$

$$k = 1, 2, \ldots \quad (7)$$

which is always negative.

We now consider k, the number of pulses that the counter can accept in any range element. If ab is small, coincidence occurs rarely. The counter is often empty and can accept as many pulses as the counter capacity in every range element, i.e., k_{max} = counter capacity k_c. If ab is large, coincidence occurs frequently and $k < k_c$. From Figure 2 it is clear that each range element has at least one blank and therefore at least one stored pulse in the counter is cleared after being used for compensation. This assures one vacancy in the counter for the subsequent range element, i.e., $k_{min} = 1$. Hence we have

$$1 \leq k(a,b) \leq k_c \tag{8}$$

To estimate the accuracy we take the average value given by

$$k(a,b) = \frac{1}{2}(k_c + 1) \tag{9}$$

In terms of the number of binary stages, m, of the counter,

$$k = 2^{m-1} \tag{10}$$

1.2.2 Division

As the result of division, it is wished to generate a SRPS with machine variable $c = a/b$, assuming $a \leq b$. Let f_b = average repetition rate of sequence B, and f_0 = clock frequency, then, by definition, $b = f_b/f_0$. This means that the average period of the divisor sequence expressed in terms of the clock period is given by $1/b$. If the number of pulses equal to the average period of the divisor sequence (expressed in terms of the clock period), $1/b$, are generated for every pulse of the dividend sequence, the sequence generated in this way has as its average repetition rate $f_c = f_a(1/b)$, or in terms of machine variable

$$c = \frac{f_c}{f_0} = \frac{f_a}{f_0} \cdot \frac{1}{b} = \frac{a}{b}.$$

Thus the sequence gives the quotient a/b.

Correspondence of the dividend, divisor and quotient sequences is shown in Figure 3. The schematic diagram of the divider is shown in Figure 4. The size of the counter determines the fraction of the number of pulses of the dividend sequence which is effective for the division operation and therefore it determines the accuracy of the divider unit.

When the number of pulses of the dividend sequence exceeds that of the divisor sequence instantaneously, they are stored in the counter. An error arises whenever pulses of the dividend sequence are discarded because of the finite counter capacity. To estimate the error, we need to estimate the fraction of the number of discarded pulses of the dividend sequence. This is exactly the same situation as in subtraction discussed in the last Quarterly Report. The correspondence of the dividend and divisor sequences is shown in Figure 5. This is the same as the figure of the correspondence between the minuend and subtrahend sequences except that the two variables now have the opposite relation, $a \leq b$. The analysis is, therefore, the same as that for

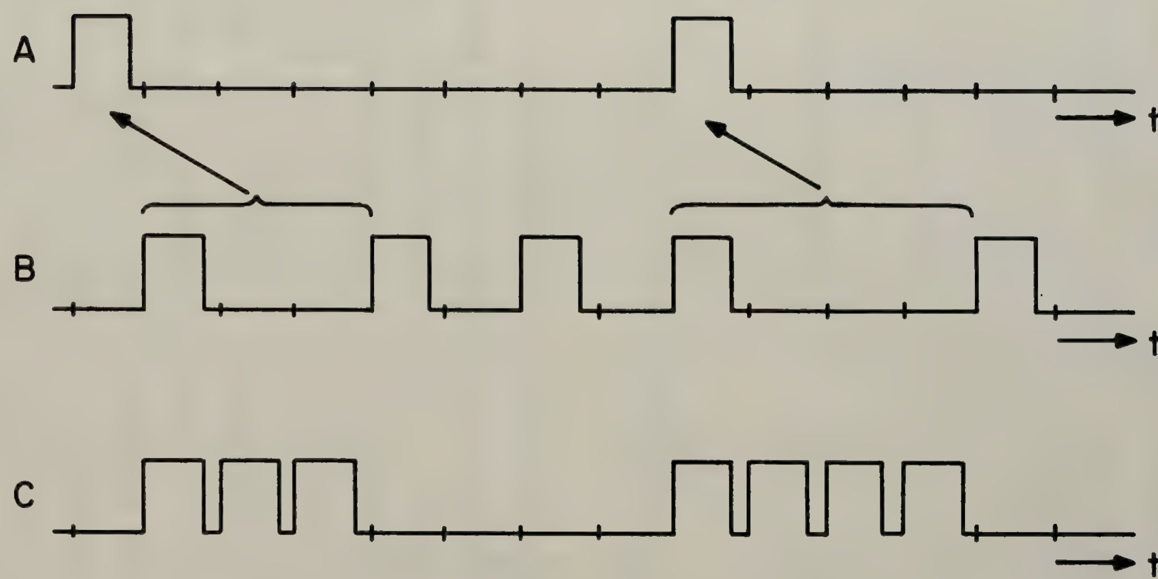
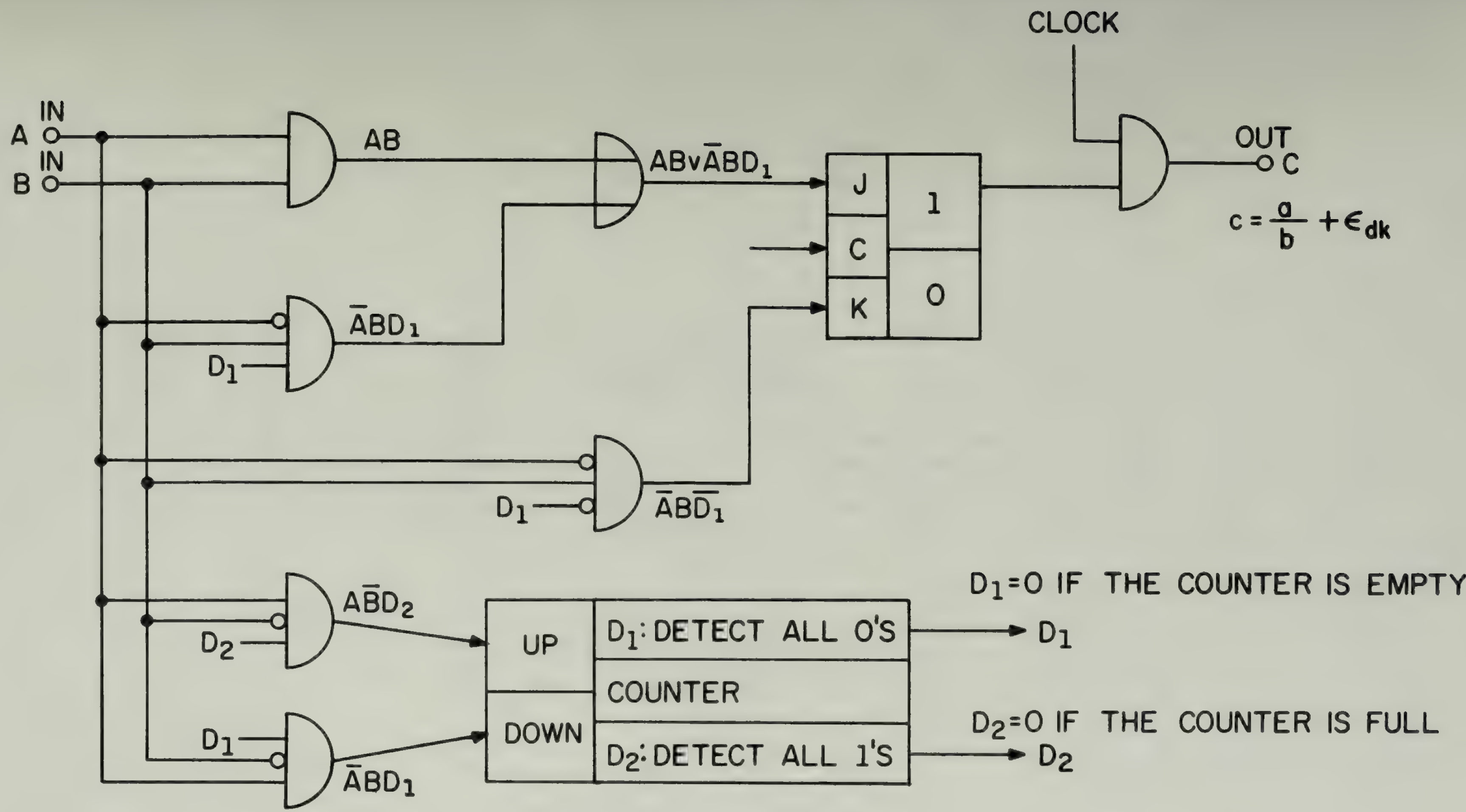


Figure 3. Dividend, Divisor and Quotient Sequences, Showing the Principle of Division.



Erratum: The A, and not the B,
input to the bottom
AND should be inverting

Figure 4. Division: $c \simeq \frac{a}{b}$.

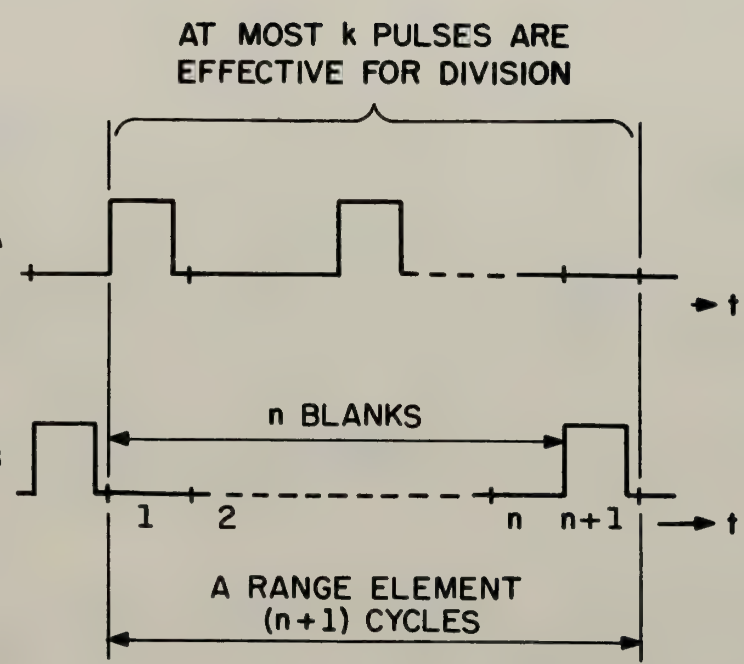


Figure 5. Correspondence of the Dividend and Divisor and a Range Element.

subtraction if a and b are interchanged, i.e., the dividend and the divisor correspond to the subtrahend and the minuend, respectively.

The effective dividend is given by

$$a_k = a[1 - \{\frac{a(1/b-1)}{1+a(1/b-1)}\}^k], \quad k = 1, 2, \ldots,$$

which is obtained from the expression for the effective subtrahend by interchanging a and b. The error of the divider with respect to the full range of the machine variable value, 1, is

$$\varepsilon_{d_k} = - \frac{a}{b} [\frac{a(1/b-1)}{1+a(1/b-1)}]^k, \quad k = 1, 2, \ldots, \tag{11}$$

which is always negative.

The pulses of the dividend sequence which coincide with those of the divisor sequence are effective for division without being stored in the counter. This introduces the same effect as in the case of subtraction. However, the correction is negligible for $k \geq 2$, and only for $k = 1$ is the error estimated more closely by

$$\varepsilon_{d_1} = \frac{a^2(1/b-1)}{b\{1+a(1/b-1)\}} [1 - \frac{b(1-a/2)}{1+a(1/b-1)}] \tag{12}$$

than by (11).

As the average value of k, we again choose $k = 2^{m-1}$.

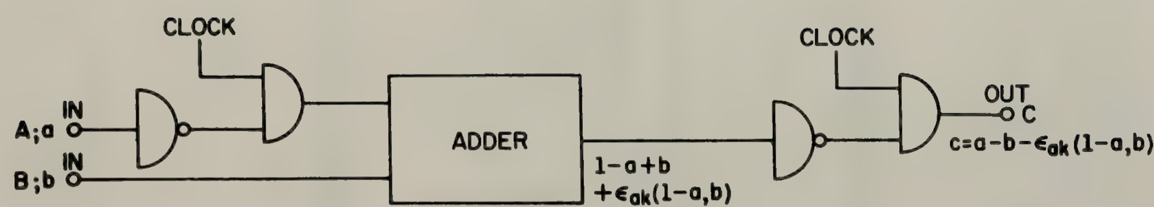


Figure 6. Subtraction Using an Adder and Inverters.

1.2.3 Complementary Relation between Addition and Subtraction

As mentioned in the last Quarterly Report, subtraction can be accomplished by the use of an adder and logical inverters as shown in Figure 6. It is also possible to show that the output pulse sequence of such a compound subtracter is identical with the output pulse sequence of the subtracter by the deletion method in terms of a Boolean expression. This means that the two methods give the same result not only in terms of the machine variable value (average quantity), but also in the instantaneous occurence of pulses. Hence the pulse distributions of both cases are identical.

In the compound subtracter using the adder, a logically inverted sequence of A is applied to the addend terminal of the adder and the output of the adder is inverted to obtain the output of the compound unit. Therefore the Boolean expressions of the UP and DOWN inputs and of the output of the compound unit are:

$$\text{UP: } \bar{A}BD_2, \qquad \text{DOWN: } A\bar{B}D_1$$

$$\text{OUTPUT: } \overline{\bar{A} \vee B \vee A\bar{B}D_1} = A\,\bar{B}\,\bar{D}_1$$

which are identical with the corresponding expressions of the subtracter by the deletion method.

In the same way, addition can be done by the use of the subtracter by the deletion method and logical inverters. Also the pulse distributions in the two methods turn out to be identical.

1.2.4 General Purpose Stochastic Computing Element

A demonstration model of a stochastic computing element, designated SCE-1 is being built. Figure 7 shows the symbol for this device.

The inputs to, and output from, SCE-1, as explained in the last report are synchronous random pulse sequences, the average frequency of

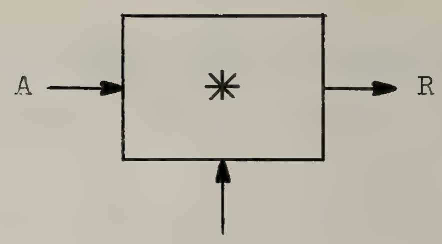


Figure 7. Stochastic Computing Element, SCE-1.

which is a measure of numerical information. The operation to be performed may be written:

$$R = A * B$$

where the asterisk is digitally programmable to be any of the binary operations of addition, subtraction, multiplication and division. Two further programmable features are included: that of commuting the inputs and the unary operation of passing either input to the output. SCE-1 is therefore seen to be capable of any of the eight operations:

$$R = (A),\ R = A + B,\ R = A - B,\ R = A/B$$

$$R = (B),\ R = A \times B,\ R = B - A,\ R = B/A$$

1.2.5 An Application

The versatility of SCE-1 makes it ideally suited to a fixed structure array computer. Figure 8 shows a three row, eleven column array with a "straight through" connection for the top row and an "up-right" connection for the others. (In the figure the inverse divide operation is indicated by a backwards-sloping slash: $\backslash$). This array has been programmed to generate a function that is a sum of repeated fractions. For such functions ($\Sigma\ f_i$), there is a simple 5-step algorithm for determining the operation of each SCE-1:

F = r/(s+t)+gh/(tw+b/(dp+y))

F = t(B)(B)s(B)+r(B)\(B)y(B)(B)p(B)dx+b(B)\t(B)wx+h(B)gx\+

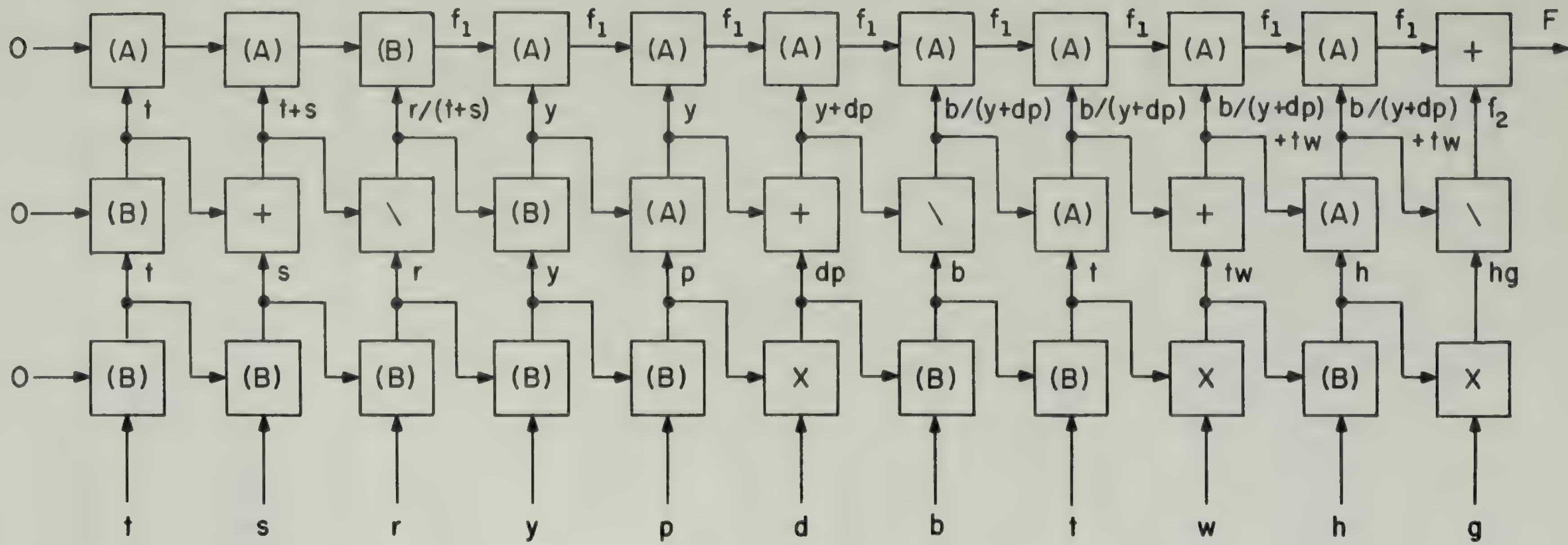


Figure 8. Array of Stochastic Computing Elements.

(i) Using a Polish notation (in which operands precede) operators and using the symbols +, -, · , (A), and (B) defined above, write f_i as a Polish string, PS, with (B) inserted after the first f_i.

(ii) Write each f_i of (i) as a PS with all products treated as single variables (called product variables) and insert (B) after the first variable or product variable of the f_i.

(iii) Write each product variable of (ii) in terms of its individual variables as a PS. Insert (B) after each variable which is not a product variable.

(iv) Combine (i) and (iii) into a single PS.

(v) "Fill in" the operators of the SCE-1's of the fixed array by reading off the PS of (iv) as follows: Start with the bottom left-hand element of the array and proceed horizontally. When more than one operator occurs consecutively, fill in vertically until the next operand is reached. At the end, fill in all unspecified elements with the operator (A).

Figure 8 shows, as an example, the set-up for the function

$$F = \frac{r}{s+t} + \frac{gh}{wt + \frac{b}{dp+y}}$$

It is easily verified that the algorithm leads to the PS given in the figure below the expression for F, and that the array effectively forms F.

1.3 POTENTIOMATRIX (Project No. 08) formerly GEOMATRIX II

1.3.1 General Properties

POTENTIOMATRIX is an electronic system utilizing hybrid analog-digital circuitry for displaying any arbitrary family of equipotential lines. The circuits are connected in a highly parallel fashion so that even with slow inexpensive components the system can realize quite high effective speeds.

POTENTIOMATRIX uses the principle that certain areas clamped to fixed voltages in an infinite conducting plane give rise to a family of equipotential lines which are solutions of the two dimensional Laplace's equation with appropriate boundary conditions. In POTENTIOMATRIX the infinite conducting plane is approximated by a finite grid of resistors.

1.3.2. Sources of Error

The accuracy of this approximation is important because it governs the accuracy of the final output display. The four sources of error which affect the accuracy are discussed in the paragraphs which follow. These relationships can also be used in "reverse" to specify a "minimal" finite grid of resistors which will suitably approximate an infinite conducting plane.

Probably the most significant error is introduced in approximating an infinite continuous plane by an infinite discrete grid. In the first case, the voltage at any point is determined by the voltage at all surrounding neighboring points while in the latter case, it is determined by only four neighboring points. This error may be expressed mathematically by examining Laplace's equation using finite differences. Assume the nodes to be unit distances apart, and expand V in a Taylor series.

$$\frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} = \nabla^2 V = 0$$

$$V(x) = V(0) + \left.\frac{\partial V}{\partial x}\right|_o x + \frac{1}{2}\left.\frac{\partial^2 V}{\partial x^2}\right|_o x^2 + \left.\frac{\partial^3 V}{\partial x^3}\right|_o x^3 + \frac{1}{24}\left.\frac{\partial^4 V}{\partial x^4}\right|_o x^4$$

+ higher order terms

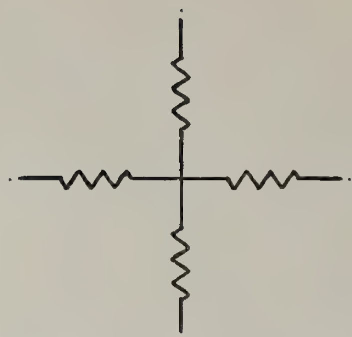


Figure 1. Grid Element

Evaluate at 2 and 4 (Figure 1) and add.

$$V(2) + V(4) = 2V(0) + \left.\frac{\partial^2 V}{\partial x^2}\right|_o + \frac{1}{12}\left.\frac{\partial^4 V}{\partial x^4}\right|_o + \ldots\ldots$$

Likewise

$$V(1) + V(3) = 2V(0) + \left.\frac{\partial^2 V}{\partial y^2}\right|_o \underbrace{+ \frac{1}{12}\left.\frac{\partial^4 V}{\partial y^4}\right|_o + \ldots\ldots}_{\text{neglect}}$$

Add the above expressions neglecting the indicated terms.

$$V(1) + V(2) + V(3) + V(4) - 4V(0) \approx \frac{\partial^2 V}{\partial x^2} = \nabla^2 V = 0$$

The error, e_1, taken in doing this is the sum of the neglected terms.

$$e_1 - \frac{1}{12} \left\{ \frac{\partial^4 V}{\partial x^4} + \frac{\partial^4 V}{\partial y^4} \right\} + \text{higher order terms}$$

The maximum value of this first term may be easily calculated. In some cases requiring higher accuracy or larger gradients, several mesh units between node output points may be necessary.

Another significant error is introduced in approximating an infinite grid by a truncated grid of finite dimensions. The grid truncation error may be established by applying a unit voltage at a single point in a grid. Using symmetry, the problem may be reduced to that shown in Figure 2. As $m \rightarrow \infty$, the grid appears infinite and $I(m)$ approaches an asymptotic value, I_o. Any current $I(m) > I_o$ is in error:

$$e'_2 = \frac{I(m) - I_o}{I_o} \times 100 \text{ percent};$$ and this error is due to the truncation at m mesh units. Since $I(m)$ is always greater than I_o, a further argument indicates the effective maximum error to be $e_2 = \frac{I(m) - I_o}{2I_o}$ x 100 percent, which is half of the previous result.

A plot of $I(m)$ vs m (Figure 3) can rather easily be determined by the relaxation method. With this plot, it is easy to determine the minimum number of mesh units, m_o, to assure some arbitrary accuracy in the grid.

Although the above analysis was carried out using a single voltage source, the result of any number of sources could be obtained by superposition, and the same accuracy assured if the distance from any source point to the grid edges is greater than m_o mesh units.

A rather surprising result is that m_o is independent of the size of the input-output region where voltages may be applied. That is, for an arbitrary accuracy, m_o units are necessary regardless of whether the input-output region is 32 x 32 or 1000 x 1000 or even 32 x 1000.

Resistance tolerance accounts for the third source of error; an error which is present in any analog system. The maximum grid tolerance would be expected to be the same as the resistor tolerance. However, in any actual case, some of the individual errors are bound

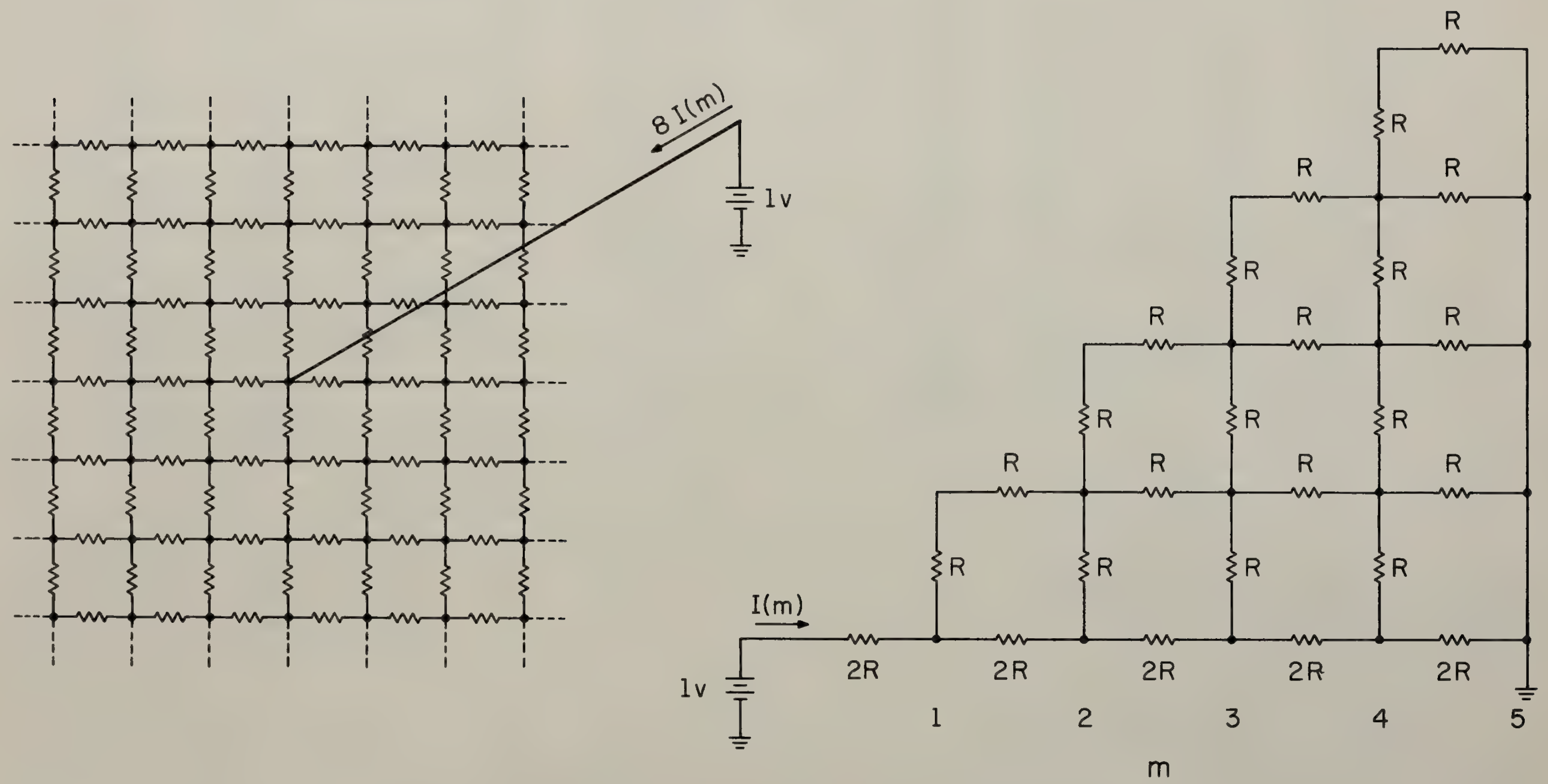


Figure 2. Finite Grid (2m x 2m)

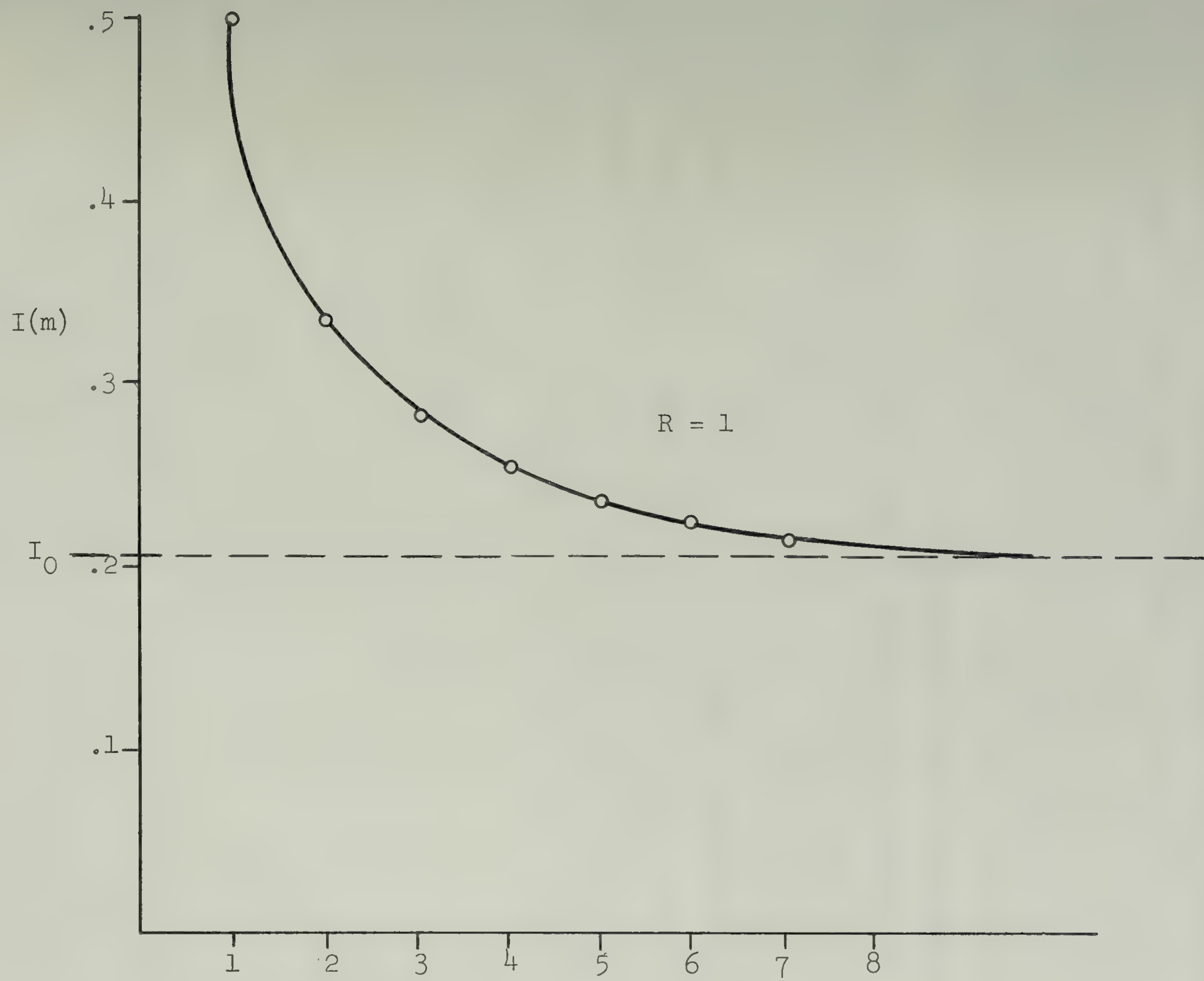


Figure 3. Source Current versus Grid Size.

to cancel each other. Liebmann did a statistical study and found that a 20 x 60 grid of 1% resistors resulted in composite errors of only .1 to .01 percent. This was verified in a model.

The detector circuit at each node draws a small current, I_{in}, which influences that node voltage slightly and establishes the fourth source of error. An upper bound can be established on this deviation. The ratio $1/8I_o$ can be regarded as the maximum Thevenin impedance, R_{Tmax}, of the grid at the point. The maximum node voltage error then is $e_4 \doteq R_{Tmax} I_{in}$. R_T decreases rapidly when nearby points are clamped, so that normally the node voltage deviations are much smaller. This error is minimized by chosing grid resistors of the smallest possible value consistent with other requirements.

This analysis has yielded a bonus solution. A somewhat classical problem involves determining the resistance between any two points in an infinite grid. The solution for two adjacent points is simple and well known. However, for non-adjacent points, it is by no means trivial. From the analysis leading to I_o, the current distribution due to one source is found; applying the principle of superposition, it is easy to find the voltage and current at any two points and thus calculate the resistance between them.

Bill Steiner

1.4 PHASTOR (Project No. 06)

In the last quarterly report certain steps aimed at improving the system stability were outlined. This involved a crystal controlled master oscillator and a counter to drive the ramp generator.

It was furthermore found advisable to use a higher beta feedback-transistor in the storage monostable. Also, temperature rise was such that the 2N967 transistors had to be replaced by 2N634's, capable of handling higher dissipations.

Using a fan to help equalize temperatures in the system, storage times of more than two hours have been attained in each of the four cells.

The final steps now involve the design and construction of the power supplies for the portable version of Phastor.

L. Wallman

2. HARDWARE SYSTEMS RESEARCH

(Supported in part by the Atomic Energy Commission under Contract No. AT(11-1) -1469).

Summary

The design of the light valve chamber for the On-Line Fourier Transform system has been modified slightly. David Casasent and Douglas Sand describe the changes and outline the basis of a noise filtering system for video.

David Rollenhagen reports on details of a scheme for Bandwidth Compression by Variable Interlace.

The other bandwidth compression project, that of Functional Encoding, is progressing under Peter Oberbeck and Art Simons, who discuss techniques of video to logic conversion and fast analog-digital conversion.

Finally, Bill Kubitz presents a detailed account of the coloring process of the Tricolor Cartograph.

2.1 ON-LINE FOURIER TRANSFORM SYSTEM (Project No. 12)

2.1.1 Aspects of a Real-Time Video/Noise Filtering System

As discussed in previous reports, the solid state light valve is a device capable of producing video image transparencies at television frame rates, providing a delay-free source for optical data processing. In this section we discuss some aspects of a particular application of this device---a system for real-time adaptive "filtering" of video images corrupted by transmission noise. Details for a feasibility study of such a system will be considered in a subsequent report.

Consider the video signal from an image pickup device such as a vidicon camera. For each frame this video signal is highly structured and consists of two types of information: the various sync signals necessary to reconstruct the raster scan parameters, and the image light levels observed at points during the raster scan. If the video signal is transmitted through some channel (for example, an a.m. carrier transmitted through space), it may be corrupted by noise. We wish to minimize the average effect of this noise by a filtering scheme.

The problem of filtering signals plus noise can be treated by well-known stochastic filtering techniques. For example, the signal plus noise could be passed through an optimal Weiner filter to maximize the signal-to-noise power ratio. However, for video signal processing, the Weiner filter and similar devices are somewhat unsuitable: first, the power spectra of both the signal and the noise must be known a priori; and second, the filtered signal is quite often severly distorted.

The concept of the power spectrum of a composite video signal is not very useful: there may be little correlation from frame to frame; and since the sync signals must predominate, the more important information contained in the image signal is somewhat "masked" out. The power spectrum of the noise can be more usefully defined, but if the characteristics of the noise are largely unknown or change with time, an a priori definition of the noise power spectrum is largely a matter of conjecture.

The problem of image distortion by filtering is more serious, since a distorted image is almost as undesirable as a noisy image. This distortion can be minimized by pre-emphasizing the image before transmission, but the necessary pre-emphasis filter again requires a priori definitions of the power spectra and entails a more complicated source system.

For these reasons we have adopted a somewhat different approach to noise filtering. The sync signal must dominate the composite video, since the image signal is useless without the corresponding sync pulses. Thus, the sync part of the composite video must be effectively immune to the transmission noise. Now if the source transmits a blank frame (zero image signal) a receiver would then have a frame containing a sample of the noise, and using the sync signal we could reconstruct a raster "image" of the noise sample.

With this image of the noise sample (and any a priori noise characteristics, such as previous noise samples), we have sufficient information to construct a noise predictor. A stochastic predictor requires only the power spectrum of the uncorrupted "signal" (in this case the noise!). The noise prediction can be made independent of the content of the desired image signal.

A noise prediction system would operate as follows. The source sends one blank frame (or as many as necessary to "prime" the predictor), followed by a frame containing the desired image. The receiver uses the noise prediction in conjunction with the signal-plus-noise frame to reconstruct the video image. This sequence of blank frames alternating with image frames could be continued ad infinitum. Each new blank frame should increase the accuracy of the noise prediction, and if the predictor is made adaptive it could compensate for noise characteristics that change with time.

A system to achieve this filtering scheme would be roughly as follows. The source could be very simple: it transmits blank frames alternating with image frames. The receiver system must contain a frame receiver, a prediction computer, and an image reconstruction device. Since we are concerned with two dimensional images (of the noise and video), the parallel computation capabilities of optical data

processing are clearly desirable for the prediction computer and the image reconstructor. The solid state light valve would allow such optical computation to proceed at real-time rates. In a subsequent report we will consider the details of a feasibility study of such an image filtering system incorporating the light valve.

2.1.2 Light Valve Design Modifications

In previous reports various features of the design of the light valve have been discussed. In particular, the proposed design was to incorporate a static magnetic field to bend the electron beam of the off-axis write gun so that incident electrons would approach prependicular to the crystal face. The present design of the light valve---now being constructed---does not include this incidence-correction field. In this section we consider some of the reasons for this modification, and briefly mention some additional features to be included in the light valve system.

In the basic light valve design the write gun must be located off the optical axis. To optimize resolution and contrast the write gun must be selected for minimum spot size (less than .002") and maximum beam current (about 10 μA); since spot size and beam current are roughly proportional, the write gun must be carefully chosen. Once selected, the write-gun must then be operated near its design center: in particular, the gun-to-crystal distance is fixed, since the minimum spot size increases rapidly for a small change from the design-center distance. Other considerations, such as the physical size of the beam deflection coils, impose additional constraints on the design of the light valve. These constraints require that the write gun be placed at about 30° from the optical axis, with a gun-to-crystal distance of about 8 inches.

If the electron beam follows a straight line from the write gun to the crystal, the electrons will be incident at approximately the write gun angle. This large angle of incidence has undesirable effects; from an experimental aspect, the secondary emission characteristics for KDP are essentially unknown, for large angles of incidence; and from a

design aspect, the effective spot size (inversely related to the cosine of the incidence angle) is increased and, correspondingly, the effective beam current is decreased. However, if the electron beam passes through a uniform transverse magnetic field, it follows the arc of a circle, and can be directed for normal incidence. It was thought that this simple method could reduce many of the problems associated with the off-axis write gun, and so a beam-correction field was originally included in the design of the light valve.

Unfortunately, for the given write-gun constraints, the beam-correction field is feasible only if it extends to the vicinity of the crystal itself, so that the correction field affects the trajectory of the erase-gun electrons. Since the energy of the erase-gun electrons is considerably lower than that of the write-gun electrons, the erase beam trajectory must follow a very sharp curve through the correction field.

In principle, the erase gun configuration can be made compatible with the required correction field. Preliminary calculations were made which indicated that the erase gun must be of a particular design to operate correctly. However, since an erase gun has never been used in previous versions of the light valve, it was felt that the beam-correction field could be sacrificed to allow greater flexibility in the design and operation of the erase gun.

The off-axis write gun (with or without correction field) imposes another difficulty: since the path length from gun to crystal is a function of spot position, several critical parameters, such as optimal focusing voltage and beam deflection gradient, are position dependent. To obtain usable spot sizes it will be necessary to control the focusing voltage by a position-dependent function (this is commonly called "dynamic focusing")---it appears that a simple linear function of position will be adequate. With the off-axis beam, a normally square raster scan is distorted into a rhomboid ("keystoning") so that the deflection signals must also be corrected for position; again, a linear function of position will be used to obtain the necessary correction.

Dynamic focusing and keystone correction will add to the complexity of this system, but should greatly improve the scan characteristics.

David Casasent

Douglas Sand

2.2 Bandwidth Compression by Variable Interlace (Project No. 14)

The thesis project described below leads to the design and construction of a system for compressing the bandwidth of television video signals. The bandwidth will be compressed by an amount inversely proportional to the rate at which the television information changes. If information between successive television frames changes very slowly, or not at all, the bandwidth of the television signal will be reduced by a factor of 64 (this factor was chosen more or less arbitrarily as an upper limit of the bandwidth compression. At this limit, the time required for the transmission of a complete television frame is approximately two seconds). If the television picture changes completely between two successive frames, there will be no bandwidth compression of the television signal.

Bandwidth compression will be accomplished by modulating the sweep speed of the electron beam within the vidicon tube of the television camera. In addition, the line scan sequence will be modified to reduce line-drift effects at slow sweep speeds. An example of the line scan sequence is shown in Figure 1 for a bandwidth compression of five-to-one.

From Figure 1 it is clear that every fifth line is scanned, and that the sweep speed is reduced by a factor of five for a five-to-one bandwidth compression. The modified rasters are interlaced in such a fashion that each successive raster "jumps" in a direction opposite to that of the last. In the case of a five-to-one compression, the first lines scanned are, in order of the five rasters, line 5, line 1, line 4, line 2, line 3. For a six-to-one compression, the order would be line 6, line 1, line 5, line 2, line 4, line 3. The pattern for any given compression ratio up to 64 should now be obvious. It is hoped that by interlacing and shifting the modified rasters up and down successively, instead of scanning all 512 lines consecutively in a single raster, there will be no observable "bar drift".

The system comprises four parts: the closed circuit television camera, the closed circuit television receiver, the horizontal and vertical deflection circuits, and the delta-information density detecting circuitry, all shown in figure 2.

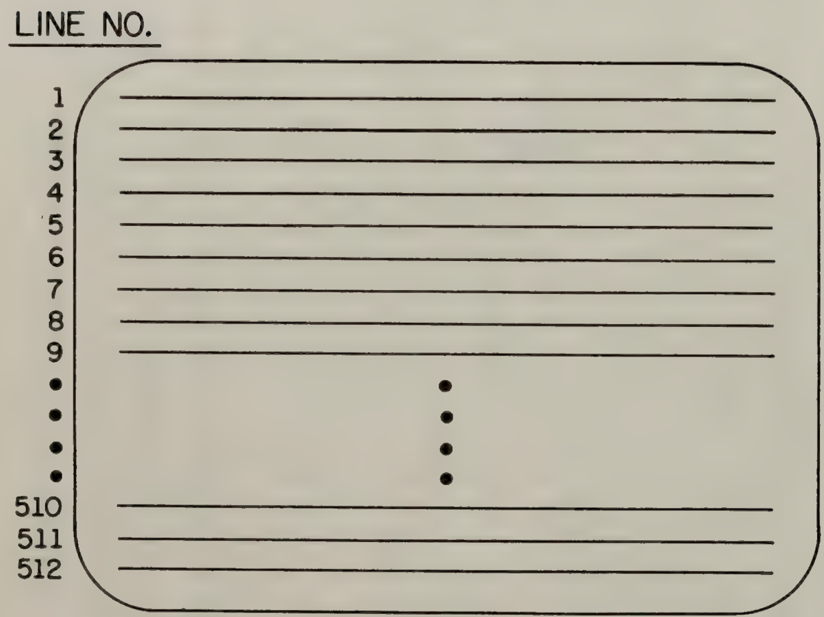
The delta-information density detecting circuitry provides a voltage proportional to the amount of information which changes between successive television frames. Each incoming frame of television information is stored on the DISC RECORDER. The incoming frame is compared with the previously stored frame by means of the COMPARATOR CIRCUIT, and the output of this circuit represents the voltage differences between the corresponding video signals. This difference is integrated over each frame by the INTEGRATOR CIRCUIT, whose output is the desired measure of the amount of information which has changed between the successive frames. The DISC VIDEO CONTROL shunts the various signals between three tracks of the DISC RECORDER.

The output of the DELTA DENSITY DETECTOR is sampled at the end of each frame and held for the duration of the following frame. The voltage from the DELTA DENSITY DETECTOR, which is thus stored, modulates the duration of the horizontal ramp voltage which is applied to the deflection plates in the camera. A relatively large voltage, indicating a large frame-to-frame change in information, will increase the slope of the ramp and hence increase the sweep speed.

The VERTICAL DEFLECTION CIRCUIT is, in contrast to the HORIZONTAL DEFLECTION CIRCUIT, entirely digital in nature. Information from the HORIZONTAL DEFLECTION CIRCUIT determines the number of lines to be skipped in each raster. For example, if the sweep speed is decreased from the maximum speed by a factor of ten, every tenth line must be scanned in each raster. The D/A CONVERTER provides a vertical deflection voltage corresponding to this information, given in digital form.

Two SIX-BIT counters determine the starting line of each raster. This information is added to the digital line count by means of the SIX-BIT ADDER in order to shift each raster to the desired position. The result of this digital operation is the application of a prescribed dc bias to the deflection plates to locate each raster.

The same camera which provides the video signal to be stored on the DISC RECORDER for use in modulating the sweep speed also provides the bandwidth compressed video signal. The possibility of system instability is eliminated by alternately switching the system between two modes of



LINE SCAN SEQUENCE

LINE NO.				
5	1	4	2	3
10	6	9	7	8
15	11	14	12	13
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
•	501	•	502	•
505	506	504	507	503
510	511	509	512	508
RETRACE	RETRACE	RETRACE	RETRACE	END

NO COMPRESSION: CONVENTIONAL T.V. RATES

TIME PER LINE $\approx$ 63.5 μSEC.
TIME PER FRAME $\approx$ 1/30 SEC = 33.3 mSEC.

RATES WITH FIVE-TO-ONE COMPRESSION

TIME PER LINE = 5 X 63.5 = 317.5 μSEC.
TIME PER FRAME = 512 X 317.5 μSEC = 0.163 SEC.

Figure 1. One Complete Interlaced Scan for a five-to-one Bandwidth Compression.

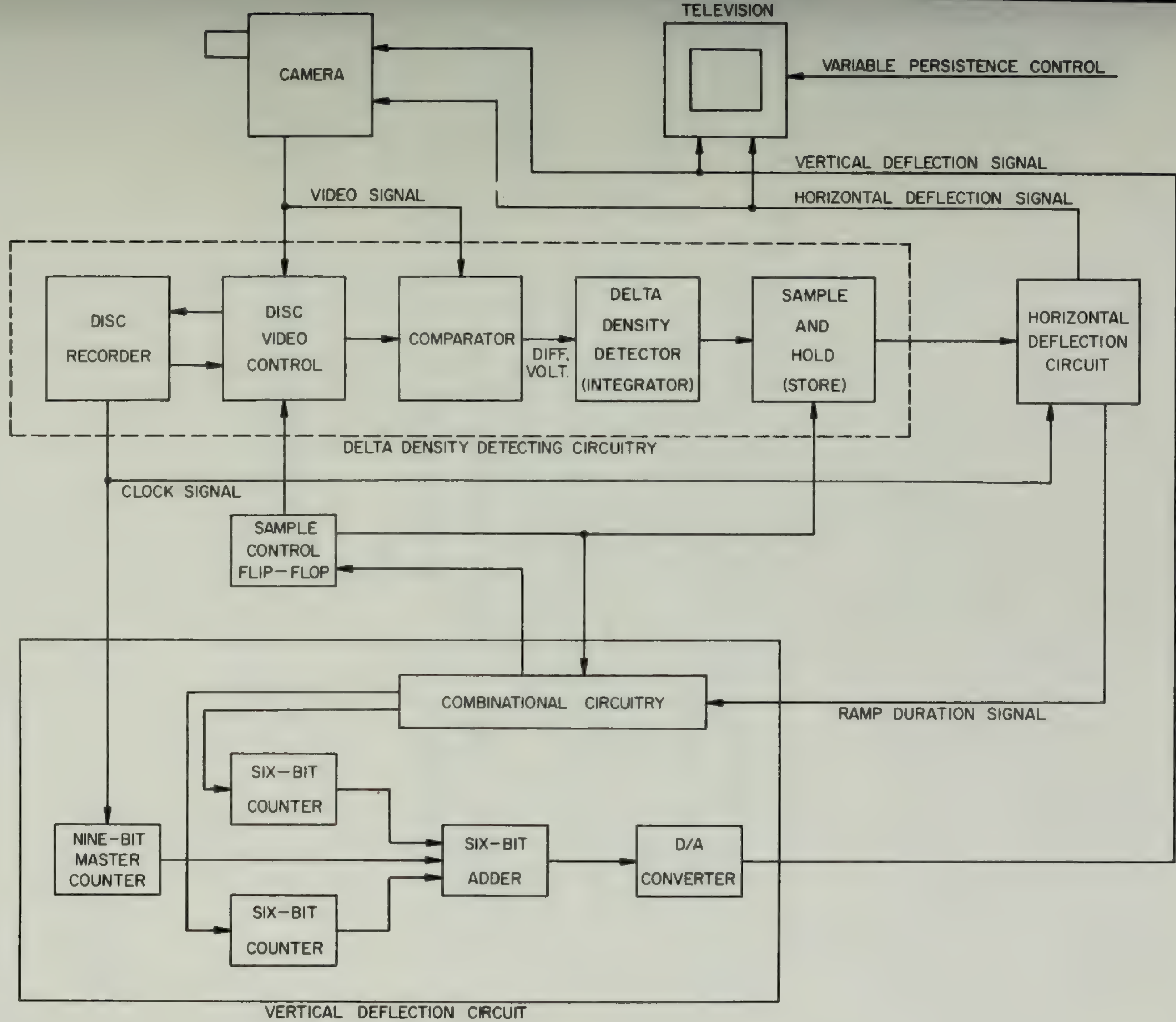


Figure 2. Block Diagram of System.

operation. The beam in the vidicon tube first sweeps out the television information at conventional television frequencies. The resulting output from the DELTA DENSITY DETECTOR is then stored, and the SAMPLE CONTROL FLIP-FLOP switches the system to the slow-scan mode in which the camera now provides a bandwidth compressed signal. At the conclusion of a complete scan, the system reverts to the fast-scan mode to determine the amount of information which has changed during the slow-scan mode. These operations are repeated, alternately, according to the state of the SAMPLE CONTROL FLIP-FLOP.

The deflection signals are also applied to the television receiver for reconstruction of the picture from the bandwidth compressed signal. In order to accommodate the different sweep speeds and provide an acceptable picture, the persistance of the phosphor coating on the picture must be modulated accordingly. At the present time, the problem of a variable persistance phosphor has not been thoroughly investigated.

The problem of combining the bandwidth-compressed video signal with synchronization signals to form a composite signal was not considered within the scope of this project. To this extent, the resulting bandwidth compression ratios apply only to the video signal and not to a composite signal.

David Rollenhagen

2.3 Functional Encoding (Project No. 15)

2.3.1 Hardware Status

As described in previous reports this system comprises a transmitter and a receiver. The major effort during this quarter was spent on the transmitter. Although the design of the receiver is complete and the hardware for building it is in hand, its construction is being postponed until the transmitter is working properly, in order to minimize the number of possible design changes.

2.3.2 Video to Logic Converter

A new transmitter circuit has been designed, the purpose of which is to convert a video signal to standard logic levels, as shown in Figure 1.

The inherent curvature of the video background (a scan position dependent phenomenon) makes the dark points difficult to detect. A modified type of differentiator circuit has been designed to overcome this problem. The circuit has a "flat topped" response, at a high enough frequency to differentiate the dark pulses, which then falls off to block high frequency noise (Figure 2).

This forms the front end of a complete circuit, shown in Figure 3, which takes the resulting differentiated video signal (the curved background having been removed) and generates from it the required logic output.

Peter Oberbeck

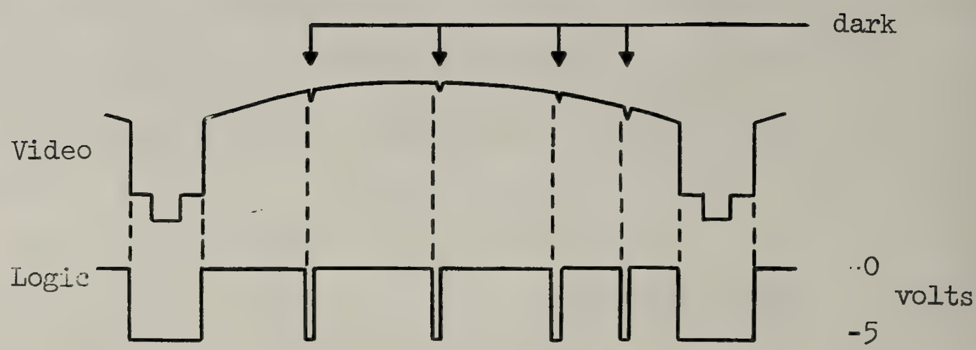
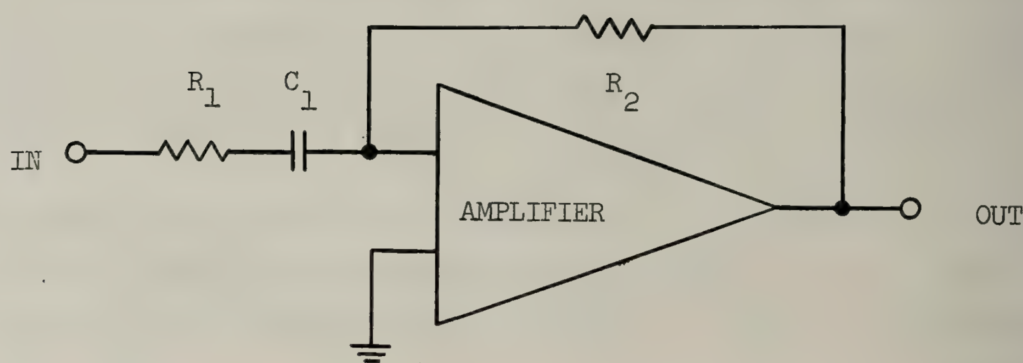


Figure 1. Video to Logic Conversion.



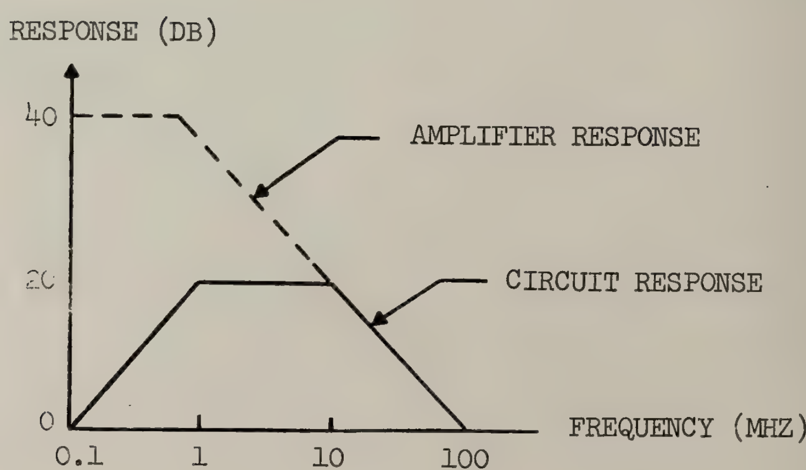
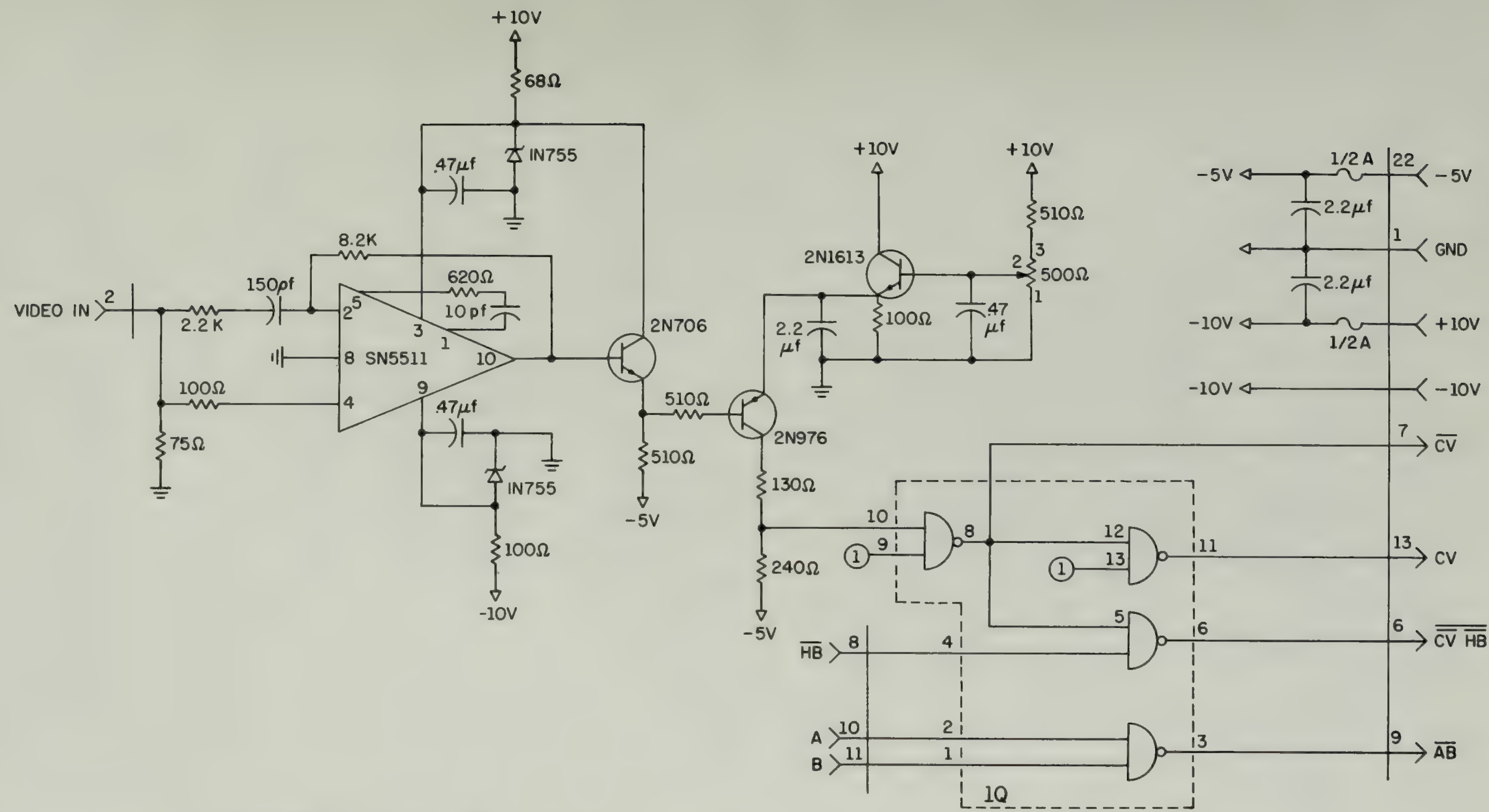


Figure 2. Differentiator Circuit and Response Curve.



RESISTORS 1/4 Watt 5%

Figure 3. Video-to-Logic Converter.

2.3.3 Fast Analog-Digital Converter

In the last report two different methods for accomplishing the conversion were discussed. A third method, however, has been introduced and was found to be the most satisfactory.

The first two techniques utilized the comparison method for determining the five most significant bits, and then a different method was used to convert the remaining four bits. In the new system, however, the comparison method is used to convert all nine bits. A block diagram of the converter is shown in Fig. 4. As described in the last report, the five most significant bits are determined by a simultaneous comparison of the input signal with 31 reference voltages and a subsequent encoding of the 31 digital outputs of the comparators. The five bits are stored in a register and fed into a 5-bit Digital-Analog converter. The resulting analog signal, corresponding to the five most significant bits, is then subtracted from the input analog signal and the resulting signal is converted into four bits in an identical manner. This method is simpler and much faster than the two previous techniques, yielding an overall conversion time of less than 1.6 μs.

The decoding and logic level converting circuits have been built on printed circuit boards. The logic level converting circuits were needed because the converter used Fairchild comparators and Texas Instruments circuits in the decoder. The circuit for the logic level converter is given in Fig. 5. The logic level converter ckt. uses a transistor and a Zener diode to shift and invert the output levels from the comparator to make it compatible with the integrated circuits of the decoding network.

Art Simons

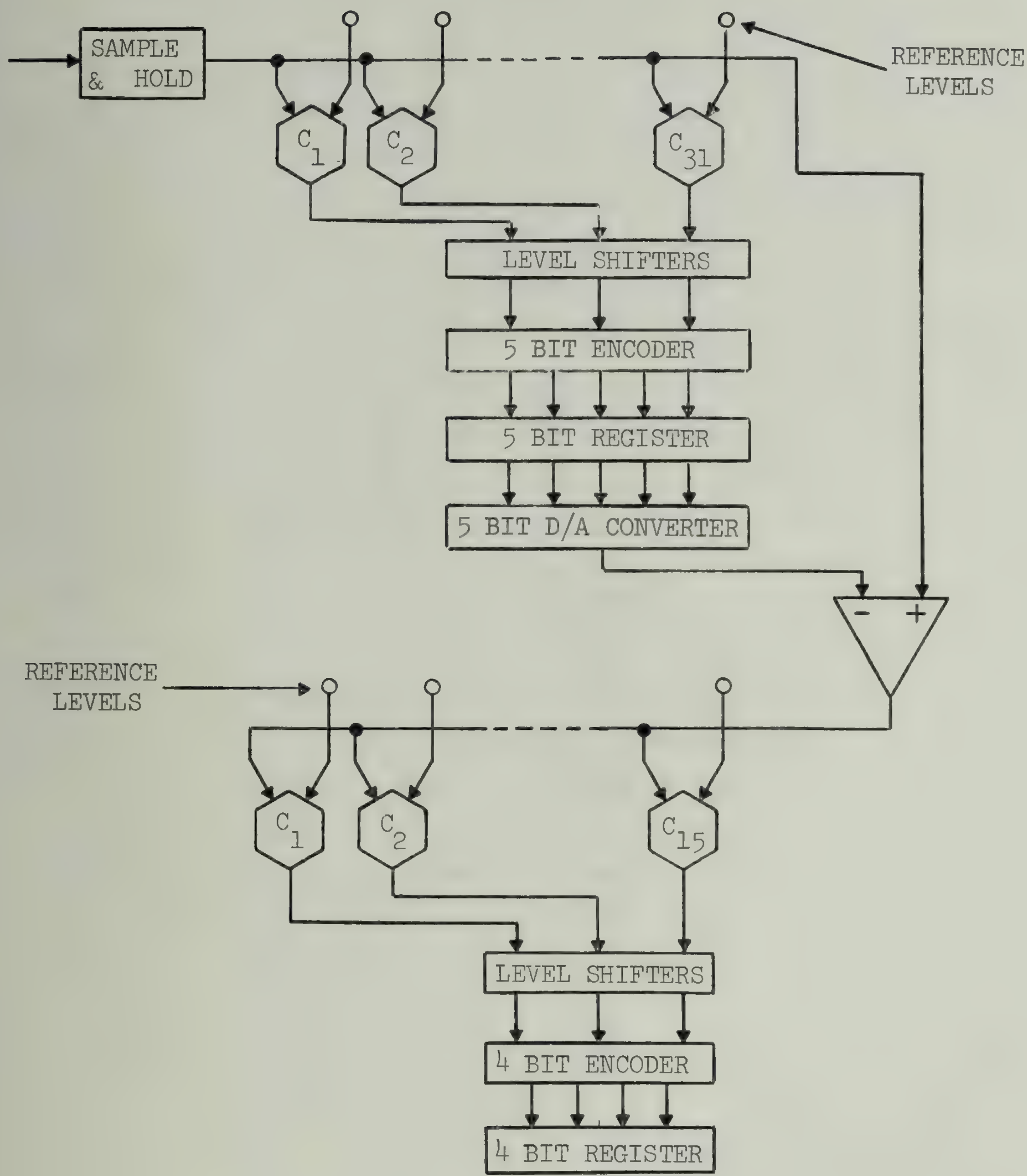


Figure 4. Analog-Digital Converter.

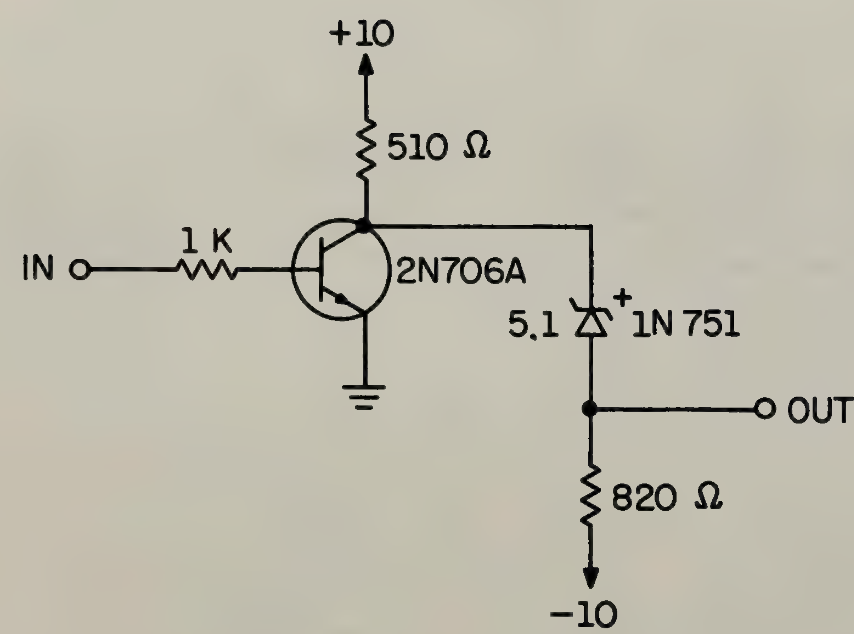


Figure 5. Logic Level Converter.

2.4 Tricolor Cartograph (Project No. 16)

2.4.1 System Operation

The Tricolor Cartograph is a graphical display system which can automatically color a selected closed area. Previous reports have dealt with some of the problems which arise in such a system and the proposed solutions. The system is self-contained and does not rely on the back-up of a general purpose digital computer.

In this report, the sequential process by which the actual coloring of areas is accomplished will be explained briefly. However, before proceeding with the discussion it is necessary to define some of the terms which will be used. The timing of the system is accomplished by means of two signals originating at the disc memory. These are the horizontal and the vertical drive pulses. The entire system has a standard 525 line interlaced television format. A horizontal drive pulse occurs at the beginning of each horizontal line. A vertical drive pulse occurs at the beginning of each vertical field. There are two fields, an even and an odd, to each frame, interlaced by shifting one field with respect to the other by half a horizontal line.

The cycle is initiated by the pen pulse at (1) (Figure 1). This is the output of the light sensitive pen and occurs, in time, somewhere inside the closed boundary whose interior is to be colored. With the occurrence of this pulse, the horizontal and vertical pen coordinates are stored in the horizontal and vertical pen position registers. At the same time, subsequent pen pulses are locked out and the Right Point and Left Point registers are set equal to the horizontal pen position (as initial points). In addition, a counter begins to count out 7 fields, (3) . This counter will terminate the entire coloring operation if the cycle is not completed within 7 fields. Following this at (4), the search begins for the Bottom Point. The Bottom Point is the point on the outline which coincides with the coordinate previously stored in the horizontal pen register. This search is accomplished at (5), assuming that no Bottom Point has been found previously. At (6), the vertical drive pulse occurs and initiates a new field. This indicates that the search for the Top Point should begin (again assuming that the Top Point has not been found). This is accomplished at (8). The search

ends at 9 when an 8 bit vertical pen coincidence occurs. There is an 8 bit pen coincidence every field and a 9 bit pen coincidence every other field. After this coincidence has occured, the search for the bottom point begins again at 4 and the entire process continues every field until some Top Point and some Bottom Point are found at 10, or else the 7 fields have elapsed. If after the 8 bit coincidence both a top and bottom point have been found, the system waits for a 9 bit coincidence at 11, if required, and then proceeds to the coloring operation. It is, of course, possible that the 8 bit and 9 bit coincidences will coincide (if the 8 bit coincidence happens to be that of the original field. Thus, from the letter A to the letter B in Figure 1 an even number of fields has elapsed.

At 12 the coloring begins. 13 and 14 represent the two operations of finding the Right Point and the Left Point between which the coloring is to be done. Since there is a one line delay between finding these points and using them, no coloring is done on the first line and the choice at 15 on the first pass is "No". After this, horizontal drive occurs signifying the end of a line. If this next line happens to be the line containing the bottom point the system awaits vertical drive before coloring the top half of the picture. Assuming, however, that the bottom has not been reached the loop returns to 12 and proceeds through 15, 16 and 17 using the points previously found in 13 and 14. Of course, on passes other than the first there is not a one line delay. At this point then, one field of the bottom portion of the figure has been colored.

After vertical drive at 20, a process similar to that for the bottom of the figure is carried out for the top of the figure. The major difference is that the test at 29 is the 8 bit coincidence test. When an 8 bit coincidence is obtained, a check is performed at 30 for a 9 bit coincidence. On the first field there will be none and the loop returns to 12 where it colors the other field for the bottom of the figure. Then at 19, 20 and 21 the coloring of the other field for the top of the picture is begun.

Finally, at 30 a 9 bit coincidence occurs and after waiting for the next horizontal drive pulse (indicating the end of the current line) the process stops and is ready to begin again at 32. The time elapsed from C to D is one frame.

W. J. Kubitz

ATC TIMING DIAGRAM

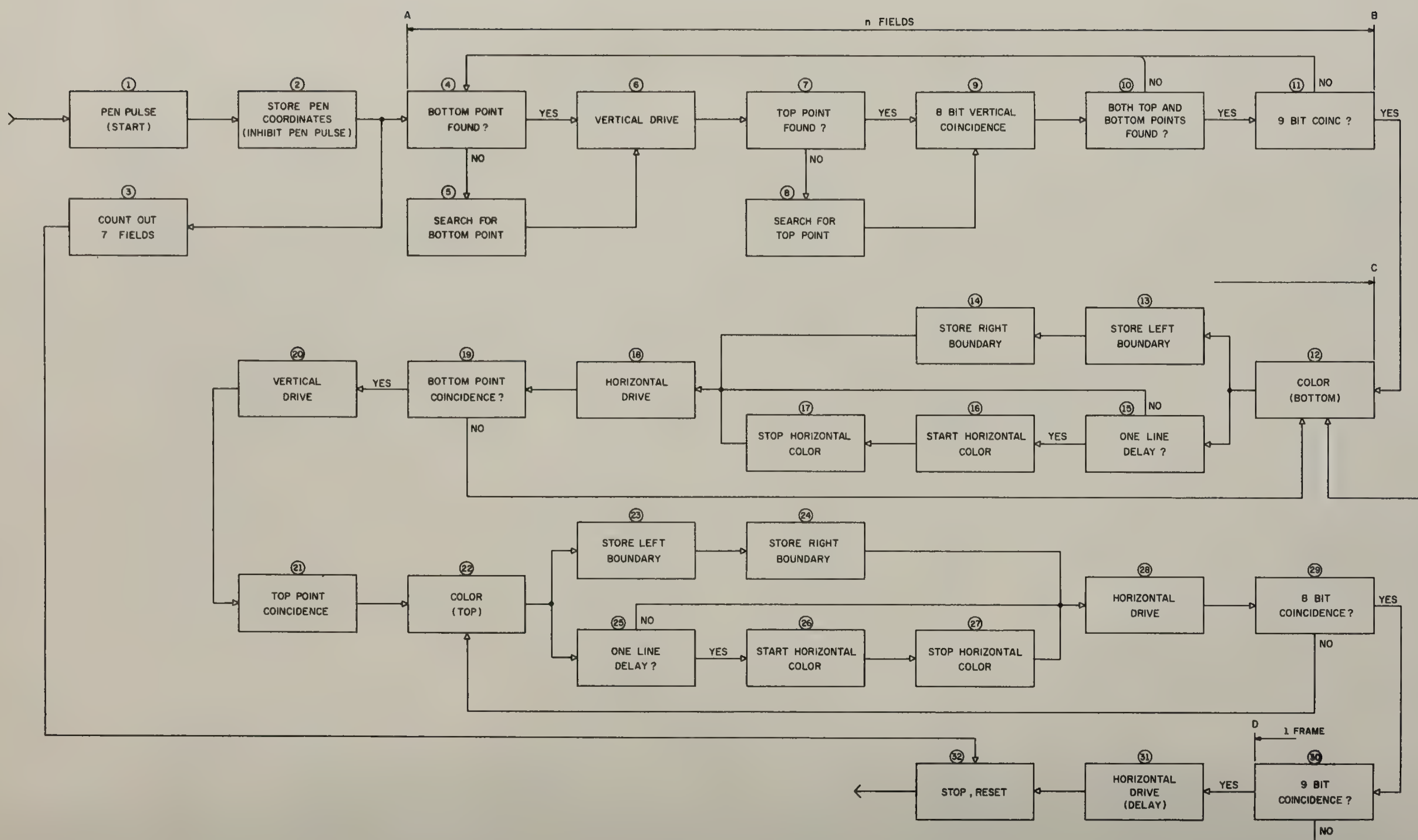


Figure 1 Tricolor Cartograph (System)

3. COMPUTER SYSTEM SOFTWARE RESEARCH

(This work is supported in part by Contract No. AT (11-1) 1469 of the Atomic Energy Commission and in part by the University of Illinois.)

3.1 Numerical Analysis - Ordinary Differential Equations

Tests have been run on the following four systems of equations:

1. $y_1' = ((R-Ay_3-E)y_1 + Ey_2)/V$, $y_1(0) = 1$

   $y_2' = W1(y_1 - y_2)$, $y_2(0) = 1$

   $y_3' = Py_1/C$, $y_3(0) = 0$

   A = .0001   E = .0065   V = .0001

   B = .083   P = 20   W1 = .0785

   C = 200   R = .001

   Stiffly stable - integrated from X = 0 to X = 500

2. $y_1' = -Ay_1 + By_1y_3$, $y_1(0) = 1$

   $y_2' = -Cy_2y_3$, $y_2(0) = 1$

   $y_3' = -By_1y_3 - Cy_2y_3 + ay_1$, $y_3(0) = 0$

   Stiffly stable - integrated from x = 0 to x = 50

3. $y_1' = y_2y_3$, $y_1(0) = 0$

   $y_2' = y_1y_3$, $y_2(0) = 1$

   $y_3' = -51y_1y_2$, $y_3(0) = 1$

   Not stiffly stable - integrated from x + 0 to X = 2

4. $y_1' = y_1$, $y_1(0) = 1$

   $y_2' = -y_2$, $y_2(0) = 1$

   $y_3' = y_4$, $y_3(0) = 0$

   $y_4' = -y_3$, $y_4(0) = 1$

   Not stiffly stable - integrated from X = 0 to X = 5

The results on the preceding page have been plotted on two series of graphs.

The first shows the relationship between the error allowed and the number of function evaluations necessary to integrate over the indicated interval. These graphs were done for methods of order two through six and for the number of corrector iterations allowed to effect convergence varying from two through four.

The second group of graphs shows the cost in microseconds over the specified interval expended in the use of the two user-provided subroutines (one to evaluate the functions, the other to evaluate the matrix:)

$$\left[I + \frac{h\beta_0}{\alpha_0} D^{-1} \right]$$

as related to the number of corrector iterations to be allowed (2, 3, or 4). These graphs were also done for methods of order two through six, and for various errors.

A new version of the differential equations program has been written which examines the order of the method used for integration after each attempt to integrate which results in non-convergence or step-doubling.

The basis for deciding on an alteration of the order is the following:

If the order of the method currently being used is K, the error in the method of order K-1 is

$$\sum_{i=1}^{n} ||C_K h^K y_i^{(K)}||$$

(n is the number of equations in the system and C is known).

This error is obtained from the K + 1st element of the y-vector

$$\left(\frac{h^K y_i^{(K)}}{K!} \right)$$

The error in the K-order method is:

$$\sum_{i=1}^{n} ||C_{K+1}h^{K+1}y_i^{(K+1)}||$$

and is estimated from the value of the predictor minus the value of the corrector which is

$$h^{K+1}y_i^{(K+1)}\left(\frac{1}{(K+1)!} - C_{K+1}\right)$$

The error in the method of order K+1 is

$$\sum_{i=1}^{n} ||C_{K+1}h^{K+2}y_i^{(K+2)}|| \text{ where } h^{K+2}y_i^{(K+2)}$$

is estimated by the difference,

$$\left[h^{K+1}y_i^{(K+1)}(X_{t+1}) - h^{K+1}y_i^{(K+1)}(X_t)\right]$$

The error in the K-order method is compared with the errors in the methods of one order higher and lower, and the order method showing the least error is used for the next attempt to integrate.

Additional tests have been made on the four sets of differential equations referred to above. The purpose of the tests is to compare the number of function evaluations necessary to integrate the system of equations over a given interval. Methods of order 2 through 6 were used and upper bounds on the errors allowed ranged between 10^{-2} and 10^{-9}. Only three corrector iterations were allowed in one attempt to integrate, since this seemed to be the most effective number.

Further tests are being run using the same sets of equations mentioned above and the same program with the exception of the coefficients which determine the methods used to integrate. Coefficients for non-stiff methods are being used in order to compare these with the stiffly stable methods used in previous tests. In general the non-stiff methods are more

effective for non-stiff equations and the stiff methods better for the stiffly stable equations, but the contrast is much more pronounced in the former case.

The differential equations program has been run successfully on the 360/50.

K. Ratliff

Most library routines for computer solution of systems of differential equations require that the user supply a subroutine which calculates values of the function(s) to be integrated. However, a problem-oriented language accepts a set of equations in some simple form and compiles these, generating machine code for whatever subroutines are needed. For example, the user may type in his equations at a remote console: Y1' = -2 * t * Y2, Y2' = SIN (t) and a compiler would accept this (along with initial values, step size, etc.) and produce an object program in machine language to calculate

$$F_i = \frac{h^{p_i}}{p_i!}\left[\frac{d^{p}y_i}{dx^{p_i}} - f_i\ (x, y_1,\ldots)\right].$$

In this example, it would generate

$$F_1 = h\left[\frac{dY1}{dx} + 2 * t * Y2\right]$$

$$F_2 = h\left[\frac{dY2}{dx} - \text{SIN}\ (t)\right].$$

A syntax-oriented compiler which does this translation is being planned for the IBM 360.

C. Ellis

3.2 Graphics Programming Systems

3.2.1 July

3.2.1.1 Checkout of the 338

Entirely too much time has been spent this month in checkout of the 338 system. The troubles found and corrected are: a memory bank completely down, a memory bank that fails intermittently, no X vector in the scope,

incomplete write up on the TCØ1, faulty deposit switch and the fact that DEC supplied DECTAPE test programs that are not equipped to deal with any interrupts other than the TCØ1 interrupts and the PDP-8 interrupts.

The fact that the DMØ1 does not work was found and it still does not work.

The flag from the 63Ø interface was found to be causing an interrupt which in turn caused the tape test programs to think that they had found a tape error. This has now been corrected by providing an enable flag for the interrupt condition from the 63Ø (see Display Memorandum Number 2). The system program was changed to accommodate this new hardware. The enable flipflop is set to Ø (not enable) by the PWR CLR signal (start key). This means that no interrupt will be caused by the 63Ø flag until the enable flipflop is set to a 1.

3.2.1.2 System-Program for the 338

New functions that have now been added to the system program are: the facilities to store text on DECTAPE, retrieve text from DECTAPE, and send text to ILLIAC II time sharing. This coupled with the existing facilities of the system program provide a complete and competent service to the 338 user (see Display Memorandum Number 5 (to be distributed)).

3.2.1.3 Programs for Use in Debugging Programs in the ILLIAC II Time Sharing Environment

There is a distinct lack of help for the ILLIAC II time sharing user in terms of access to his core load in a symbolic fashion. Planned and in the coding phase this month are a pair of programs to provide some help for the time sharing user.

One of the programs is a prepass to NICAP. The other program is a run time subroutine in the user's core load.

An example of the usage of these two programs will be instructive.

Suppose that we have a program named "A" that is to be debugged. Suppose further that this program is written in NICAP. The first step in using the debugging system is to put the program A through the prepass phase. This is done with the following BOOTS II commands:

Command 1: RDONLY OOO

Command 2: RUNIO A; NEWA

Command 3: RUN NAMEX**

Command 1 allows the user access in a read only fashion to my files. (The ID is three letter O's rather than three zeros.) Command 2 sets up the file correspondence and command 3 causes the program A to be processed by the program NAMEX.

The program NAMEX inserts a call to the run time routine "FODER" (Fontaine's own debugger) at each entry point to the program A and at the end of program A inserts a table that gives the BCD names and addresses of each label and address used in the NICAP program. The call to "FODER" is merely to let the "FODER" routine know the location of the table and to provide the address of the last used entry to the program A.

This done, the program NEWA can now be NICAPed and put into execution along with the program "FODER".

"FODER" also contains an entry point "BREAK". If this part of the routine is invoked in program A by use of the NICAP statement:

CALL BREAK

Then there will be a print-out giving the location (symbolic if possible) of the call of the routine break.

Then the user will be given an input request on file Ø of his files (usually file zero is the console). At this input the user may ask for by name any location in his program A (or any other included program that has had the same treatment). The octal contents of that location will be printed out followed by another input request. A blank line sent in will cause the "BREAK" routine to return to the calling program.

Also the user may give a variable name and the new octal contents of the location. In this way simple patches may be made and key data words changed.

<VARIABLE NAME> <BLANK OR FOUR OCTAL QUARTER WORDS>
<VARIABLE NAME> + <OCTAL CONSTANT> <BLANK OR 4 QW>
<OCTAL CONSTANT> + <VARIABLE NAME> <BLANK OR 4 QW>
F1 <BLANK OR FOUR QUARTER WORDS>
F2 <BLANK OR FOUR QUARTER WORDS>
F3 <BLANK OR FOUR QUARTER WORDS>
F4 <BLANK OR FOUR QUARTER WORDS>
F5 <BLANK OR FOUR QUARTER WORDS>
F6 <BLANK OR FOUR QUARTER WORDS>
F7 <BLANK OR FOUR QUARTER WORDS>
AMOST <BLANK OR FOUR QUARTER WORDS>
ALEAST <BLANK OR FOUR QUARTER WORDS>
RETURN <BLANK OR FOUR QUARTER WORDS>

The variable names are names in the program (A for example) and the F1 through ALEAST are the names of the ILLIAC II registers by that name and RETURN is a register given in the form:

Ø56ØØ XXXXX ØØØØØ ØØØØØ

Where XXXXX is the address that the break routine will go to when a blank line is received. By patching this location the user can control where his program resumes execution.

3.2.1.4 <u>ILLIAC II CAPS Programs</u>

The above programs are intended to be a tremendous help in debugging the CAPS programs in the time sharing environment. These programs are still in the planning stage and are to be coded soon.

3.2.2 <u>August</u>

3.2.2.1 <u>338</u>

More hardware difficulties in the 338 have been detected. The memory on the 338 is not in very good shape. Intermittent failure in memory bank 2 makes debugging programs in that memory bank very difficult. The DEC field service representative was here to work on the memories and install various modifications to the 338. The modifications went well but the memory still is not right. At this point, I think that the whole memory should be serviced altogether and gotten into shape before the warrenty runs out.

The DRAWIN program of T. Y. Lo's and my text manipulating program were successfully joined and some revisions have been made, others suggested and will be made in the fall.

Several Display Memoranda were produced this month providing documentation and further information on the 338.

3.2.2.2 ILLIAC II

The design and implementation of a list processing language is now in the active phase. The design is now complete (for this iteration) and coding and debugging are taking place. A further discussion of the list language will be available in the future.

3.2.3 September

3.2.3.1 338 Hardware

Another in a sequence of 338 machine faults was detected this month and later corrected. The fault was that the 338 could not be microprogrammed to clear sector bits, clear coordinate bits and enter data state all in the same memory referrence. The fault was attributed to an incorrectly installed engineering change order installed by the DEC field service representative. This fault has now been corrected.

Some fleeting troubles have been noticed but the symptoms have not persisted long enough to discover the fault much less correct it. The memory is still not in too great a shape. Memory bank 2 fails consistently (MTBF = 1-2 hours).

It is my fervent hope that the 338 hardware can be brought up to an acceptable level of good operating stability and that it will stay there.

There has been some experimentation with applying colored filters to the display face to help the problem. We have blue and orange filters with different hues. The blue filters do not affect the light pen but actually accentuates the flicker. The orange filters reduce the flicker but the light pen is no longer able to cause interrupts.

The physical problem of mounting the filters is to be solved by moulding the filters to the shape of the tube and use the filters as a sort of cap to be placed over the tube face.

3.2.3.2 <u>338 Software</u>

The 338 programs--Text Manipulator and Drawing--are undergoing some few changes. Currently implemented is the facility to communicate with ILLIAC II while in the execution mode or while in drawing mode (while the flow chart is displayed on the screen). Also implemented is the feature that the last flow chart is displayed while the user is in the file mode.

Scheduled for implementation in October are light buttons that are logically equivalent to the push buttons and new improved light pen tracking algorithms.

3.2.3.3 <u>ILLIAC II Software</u>

The CAPS system has now gone through a design phase and is currently being implemented. The system will be described in detail in a separate document now in writing. The implementation is coded and debugged up to the point of actually processing flow charts. The system will process lines of text that could come from flow chart symbols. The flow chart processor is coded and is currently being debugged.

F. K. Richardson

3.3 <u>PBD-338 End of CAPS</u>

3.3.1 <u>July</u>

The Move, Delete and Exchange modes of the push botton for man-machine communication on the PBD-338 system have been completely checked out during this month. Some modification has been made to speed up the light pen hit response in the Move mode. The Drawing program and these flow-chart manipulating programs are now filed on the Dectape Library System. In order to fully utilize the memory capacity of the PBD-338 system, the Drawing program and those programs to handle flow-chart manipulation are under modification so that they will be loaded into memory field 2 whenever they are called from the Dectape Library System, and when a source table file is loaded into the memory field 0, control will automatically transfer to these programs in memory field 2 to develop a display file for display and manipulation.

Work in progress includes also the coding of the program to implement the TEXT EDIT mode and SAVE FILE mode. The function of the TEXT EDIT mode has been described by Fontaine K. Richardson in his note, Proposed Implementation of the CAPS Display Console Computer Software System, File No. 725-2, January 12, 1967, and the text manipulation used in TEXT EDIT mode has been implemented by him. In the Save-File mode, PDP-8 will stop the display, type out the last location of the source table and call in the Dectape Library Systems for users to save the source table file for later use.

3.3.2 August

In order to fully utilize the memory capacity of the PDP-8 computer, the Drawing program and the flow-chart manipulating programs have been modified during this month so that when they are fetched from the Dectape unit they will be automatically copied into memory bank 2 and from there they develop a display file into memory bank 1 from the source table in memory bank 0, and initiate the display.

The push-button function for TEXT EDIT and SAVE-FILE modes has been implemented during this month. A new function has been implemented to enable communication among user, display unit, and system. When push button 5 is on, keyboard flag is up or remote interface interrupt flag is up, the display will be stopped and control be transferred to the system program for any possible operation and when control is back to the flow chart manipulating programs, display will be re-initiated.

It is in the testing and check-out phase on these programs.

3.3.3 September

The check-out work of the Drawing program with the new added features for three way communication among users, display unit and system have been finished. The program is now in good working condition.

Some changes have been incorporated into the Drawing program during this month in order to speed up the interrupt handling process and display resumption. Some of these changes are as follows:

1. When interrupted by remote interface or keyboard flag the Drawing program will yield control to the system without stopping the display, and when the control is transferred back from these interrupt handling programs

the display will be either reinitiated or undisturbed depending on whether the source table file has been changed or not.

2. When the save-file mode is entered by pushing push-button 11, the display is not stopped and control is transferred to the Dectape Library System.

3. The number of characters to be displayed for each text symbol in a flow chart has been increased to 48 for the first line, so that a little more message can be displayed.

With the new added feature on PBD-338 hardware, work is going on to incorporate into the Drawing program an alternative way of mode change in flow chart manipulation. The improvement of tracking facilities due to the availability of the new installed light pen sense indicator is under consideration and programming.

T, Y. Lo

3.4 PL/I Interpreter

A number of routines for the syntax check part of the PL-I compiler have been written.

All the line number handling has been coded: the syntax check of line numbers and a table search to see if the line number has already been used.

The keyword checker for statement-type defining keywords has been coded; it is done by a character-by-character compare with the dictionary entries having the same number of characters.

A similar routine for checking attributes in declare statements has also been coded.

An error routine has been coded, which prints out the EBCDIC error code and resets all the buffer pointers in case of fatal errors.

A macro named GNBCR has been coded which reads blanks until a non-blank character has been reached.

A macro named PØPCR has been written which loads a specified index register from a specified buffer and decrements a specified index register. This and PUTCR can be used as "push" and "pop" operations for stack manipulation.

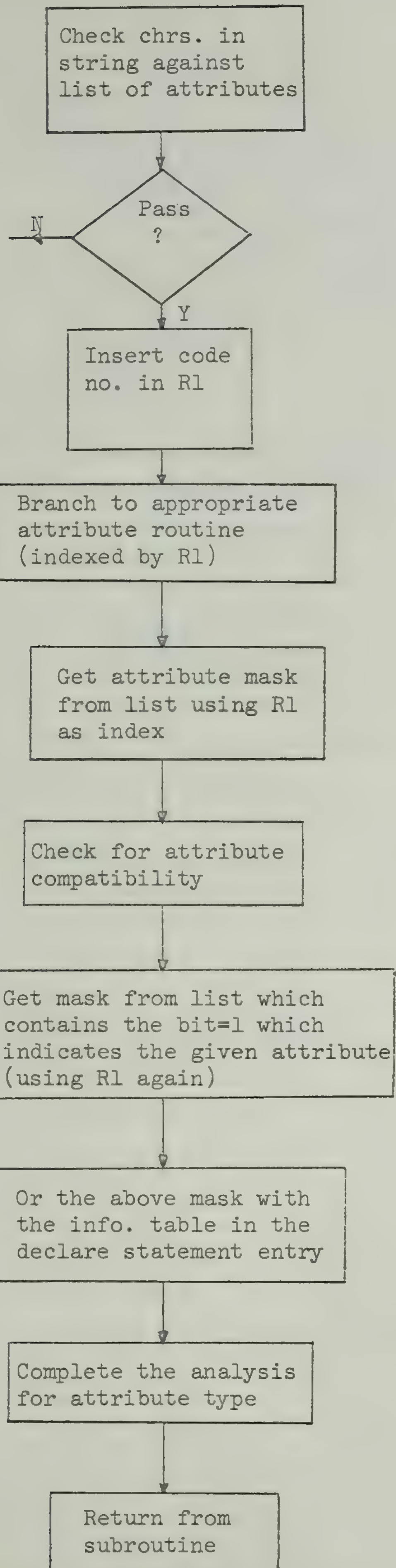
Coding the DECLARE statement syntax scan from the previously written flow charts is about half completed: the unimplemented attribute routines have been coded, and ARRAY, which syntax checks the dimension list for an array declaration, has been coded.

The conventions for "pass" and "fail" exits from subroutines have been decided upon and the form and types of parameters for the EXPRESSION routine, which syntax-checks arithmetic and logical expressions, have been decided upon.

The routines to syntax check the attributes DEFINED, BIT, LABEL, ENTRY, and RETURNS have been written. Work on the INITIAL routine has begun.

Each of the above requires a secondary string entry, in general, and the machinery for operating on the secondary string for each attribute is about the same, and will probably be converted into a series of subroutines for the purpose of optimization.

The following page is the general flow of control for the syntax check of attributes.



J. Christopher

3.4.1 July

The I/Ø and table conversion routines have been coded and are now in the advanced debugging stages. The test program being debugged will read in (a) card(s), convert FBCDIC to BS, give a SNAP (DYNAMIC DUMP), re-convert, print and punch the original card(s).

The identifier checking routine has been written and it is hoped that it will be debugged by early August.

3.4.2 September

The I/Ø facilities of the Syntax Scan for the Time Sharing PL/I Executer have been debugged. Most of the macros have been debugged and put onto the disk.

At present the identifier checker routine is being debugged.

W. W. Demlow

4. ILLINOIS PATTERN RECOGNITION COMPUTER: ILLIAC III

(Supported in part by Contract AT(11-1)-1018 with the U.S. Atomic Energy Commission and the Advanced Research Projects Agency)

4.1 Introduction

Illiac III is an experimental computer being designed and constructed by the Department of Computer Science as a first foray into the world of high speed visual data processing. Besides providing normal computational facilities, the machine includes a parallel processor for visual data processing (the Pattern Articulation Unit) and an extensive complement of visual input/output equipment.

This Quarterly Progress Report resumes the practice of regular synopses of the machine design and implementation, as well as concurrent surveys of the status of associated system programming. Rehabilitation of the area housing the Illiac III, following our disasterous fire of March 1967, is now complete. The exigencies of the recovery from the fire damage are now largely memories relegated to the past.

Also reported here are developments (funded by the Advanced Research Projects Agency) which attempt to provide picture processing facilities for remote users with only moderate image-processing demands. The strategy here is to extend the concept of time sharing. Users will communicate with the central image processing facility (Illiac III) via a video communications net. Intimately associated with this latter development is the evolving concept of an Information Resource Center.[1] Work is reported on the engineering of microform image files, text reformatting, and elements of information retrieval.

Section 4.2 outlines the system programming developments, which are then discussed in Sections 4.3 - 4.8. Section 4.9 provides an outline of the Illiac III computer system (hardware). The status of each area of hardware design and fabrication is then summarized in Sections 4.10 - 4.16. A bibliography of publications in the October 1, 1966 - September 30, 1967 contract year is given in Section 4.17. Finally Section 4.18 lists the staff of Illiac III, as of November 1, 1967.

The level of status description in the following sections varies widely, and reflects in part whether detailed manuals and reports are either currently available or soon to be issued. Current documentation is normally referenced in context.

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[1] B. H. McCormick and A. M. Richardson, "Design Concepts for an Information Resource Center", Department of Computer Science, Report 203, May 1966.

4.2 Outline of Programming Developments

The section numbers of the outline below correspond to section headings of the Progress Report.

4.3 Illiac III Simulator for the IBM 360

4.3.1 Overall Strategy

4.3.1.1 Introduction

An Illiac III Simulator is being written in Assembler Language for the 360 series machines, designed to operate under ØS/360.

On Pass I, the following hardware will be simulated:

a. Taxicrinic Processors (TP)
b. I/Ø Processors (IØP)
c. Arithmetic Unit (AU)
d. Pattern Articulation Unit (PAU)
e. Exchange Net (XN)

This pass will simulate all orders not involving the Interrupt Unit.

Using this simulator, we expect to:

1. (Machine-wise)

   a. Discover awkward or omitted instructions.
   b. Clarify definition of each instruction.

2. (Programming-wise)

   a. Check out the IBAL Translator, currently in progress.
   b. Investigate systems programming.
   c. Allow potential users to familiarize themselves with the proposed instruction repertoire.

4.3.1.2 Organization

Each of the processors (TP's, IØP's, AU's, PAU) is simulated by one or more subroutines, all of which share a common area (the Exchange Net). Overseeing the entire simulator is a "Dispatcher" Routine which simulates time sharing between the 4 TP's and 2 IØP's by allotting each in turn an increment of time. The "Dispatcher" monitors the processor operation and switches processors when the allotted time slice is exceeded.

4.3.1.3 Simulation Design Philosophy

The attitude has been taken that the simulation should proceed in a form as close to the actual hardware as possible. In this way, the design logic may be checked, and, hopefully, awkward constructions may be modified.

In this vein, all programmable registers have been simulated as well as the several internal registers. Because of this, simulator dumps should be meaningful to the designer and maintenance engineer, as well as to the programmer.

4.3.1.4 Status

The overall program flow between processors has been specified. All routines necessary to simulate a Taxicrinic Processor on Pass I have been specified, flow charted, programmed and debugged.

R. M. Lansford

4.3.2 Taxicrinic Processor Simulation

The Taxicrinic Processor (TP) has been simulated on the IBM 360 in a manner as close to the hardware construction as possible. Most TP registers, whether they are programmable or not, have been simulated. The information flow of the TP and all instructions are handled by subroutines.

The routines for information flow can be grouped into four groups:

1. Memory Access: The simulated memory can only be read or written one double word (at a natural double word boundary) at a time; therefore two routines are provided to read from core and write into core. A third basic routine is provided to construct the operand address (including indirect addressing) to be read from or written into.
2. Operand Stack Operation: 6 routines required.
3. Fetch Instructions: 4 routines required.
4. Decode Instructions: 4 routines required. (Includes pointer stack operation)

Every instruction is then written as a subroutine which may call any routine mentioned above. At present, only the contiguous access mode of operand storage has been simulated; the partitioned mode will be simulated later.

A routine has been written to initiate the TP, clear the operand and pointer stacks and set up the necessary base registers and pointer registers. A dump routine is also available to dump out the contents of all registers, as well as (upon demand) contents of core.

Status: The routines to simulate TP hardware blocks have all been coded, many are now completely debugged and documented. The routines to simulate instructions are under code checking. For complete simulation of a Taxicrinic Processor, approximately 4000 assembler language instructions are required.

Ping Koo

4.3.3 Input/Output Processor Simulation

4.3.3.1 Philosophy of Design

Programmable aspects of the I/O Processor are of first concern in this simulation. Thus command fetch and command execution are simulated at the hardware level of detail.

But channel servicing is not being programmed from the detailed engineering flowcharts because of a previous engineering simulation of this part of the I/O System. Instead, a short pseudo-simulation is designed for the device-interface part of the I/O Processor.

4.3.3.2 Status

The subroutines which simulate the Program Registers are in three stages of completion: 1st stage-Engineering Flowcharts; 2nd Stage-Programming Flowcharts; 3rd Stage-Code. All routines are complete to the second stage and much of the machinery for command fetching and execution of device-independent commands is in the third stage, coding.

Linda Katoh

4.3.4 Arithmetic Unit Simulation

The Arithmetic Unit Simulator is an independent module called by a Taxicrinic Processor and communicating with it via the Exchange Net.

Since the data format for fixed (both short and long) and floating numbers is exactly the same for the IBM 360 and Illiac III, no hardware constructions (such as signed digit subtractor) are actually simulated. For decimal arithmetic, the decimal data is first converted to the format used in 360, then executed by the corresponding 360 order, and the result converted back to the Illiac III format.

The ADD, SUBTRACT, MULTIPLY and DIVIDE orders can be executed by the 360 arithmetic units. However a special routine must be provided to detect the exceptional conditions and identify the bogus results. The data conversion orders: convert to decimal, convert to floating and convert to long fixed, must be simulated by the same logic sequence used in the hardware design; there are no appropriate facilities available on the IBM 360.

The whole simulated arithmetic unit will be treated as one program plus a routine for exceptional conditions. Approximately 1500 instructions are required.

Ping Koo

4.3.5 PAU Simulation

4.3.5.1 Design

The PAU Simulator will be a relatively independent module called by a Taxicrinic Processor and communicating with it via the Exchange Net.

In Pass I, it is intended to simulate all 4 modes of PAU operation on a 32x32 raster only. In Pass II, the raster size will be increased to an optional 64x64 raster, and (memory permitting) to an optional 128x128 raster. These larger raster sizes are primarily useful for the development of image processing algorithims without prematurely having to worry about raster border effects.

4.3.5.2 PAU Simulator Status

Only very preliminary design work has been done on the PAU simulation. The internal data storage format has been specified and a few instructions have been flowcharted. The simulation procedure models the earlier implementation here of the PAX language.

R. M. Lansford

4.4 Structure of the IBAL Translator

4.4.1 General Pass Administrator

The IBAL translator has four passes. Each pass makes a sequential forward scan of the complete program string. Accordingly input and output to secondary sequential storage is, in general, necessary during each pass.

Input to Pass 1 is the IBAL program string. Input and output from intermediate passes is in a byte string format. The same routines are used for input, output, packing, and unpacking operations on all intermediate program strings. Double buffering is used for both input and output. A program whose intermediate strings remain shorter than the buffer length, a variable to be set empirically, will remain in fast core during the entire translation.

The final output from Pass 4 is the Illiac III program segments, data segments, and run-time linkage tables.

4.4.2 Pass 1

Input to Pass 1 is the entire source program read as a string of 8 bit coded characters read from the input file. Pass 1 performs the following functions:

1. Interprets the variable input line format.
2. Transforms from character codes to internal numbers.
3. Maps compound punctuations, unsigned integers, reserved words, names, and labels into single internal numbers, accompanied possibly by Symbol Table line entries.
4. Constructs the Block List, which reveals the block structure of the program, and the Symbol Table (organized by blocks) which contains all declared symbols.
5. Deletes comments and blanks.

Pass 1 is written in sufficient generality so that it may be easily modified to apply to other languages of the Illiac III Information System. The input format allows variable length instruction (statement) lines and the insertion of formatting routines, triggered by a tab switch on any or all of the columns of a line. The number and lengths of reserved words are variable, and routines may be inserted to be called after scanning any reserved word. Also an internal number may be a variable number of bytes long.

The Pass 1 recognition is done by a relatively small finite state transition matrix. Basic changes can be made by modifying the entries in this variable matrix. Subparts of the pass, such as recognition of block structure, can be omitted easily by changing an entry in the Reserved Word Execute Table.

4.4.3 Pass 2

Pass 2 performs a complete syntactical check of the source program. The method uses a state transition matrix in conjunction with one stack. The matrix is used to check for all possible, legal or illegal, syntactical structures.

Syntactical errors are classified as 'fatal' or 'non-fatal'. Non-fatal errors are those which can be corrected without altering any previous output and where the proper correction is fairly obvious. Fatal errors, on the other hand terminate the translation after Pass 2. After each fatal error an attempt is made, by using the information in the stack, to back up a limited distance, delete the smallest illegal construct, guess the intended state, and resume checking. This process is facilitated by special error states in the state transition matrix. If the attempt seems unsuccessful, a larger construct will be deleted: the worst case here is deletion of the entire program. Both fatal and non-fatal errors cause diagnostic printouts.

Pass 2 constructs all the lists needed by Pass 3 in order to generate machine code, and performs semantic-type checks. In particular, data descriptors are filled in and the legality of data references is checked. Lists needed for machine pointer register allocation are built at this time.

Unique identifiers in each block are replaced by references to the Symbol Table. Internal file names used in dynamic references must be retained, but names used only in static references can be replaced.

New syntactical symbols are added to the program string in Pass 2 to guarantee a unique parse in Pass 3. For example, a new closing delimiter is introduced when the same delimiter can terminate two different constructs.

4.4.4 Pass 3

In Pass 3 machine code generation is performed by operating on a legal program string. Operator precedences and one operator stack are used to parse the string rapidly. In many cases, the Illiac III code produced corresponds directly to the suffix form produced by the precedence parse. Thus a compile time operand stack, and a execution time intermediate result stack are unnecessary for this pass.

As a simple example consider the compilation of the expression ' a * (b + c - d * e); ' . Here B represents the bottom of the operator stack and small letters are symbolic data pointer names. An outline of the compilation process is given below.

Input	Operator Stack	Output Code
a	B	PUSH , a
*	* B	
(	(* B	
b	(* B	PUSH , b
+	+ (* B	
c	+ (* B	PUSH , c
-	(* B	ADD
	- (* B	
d	- (* B	PUSH , d
*	* - (* B	
e	* - (* B	PUSH , e
)	- (* B	MPY
	(* B	SUB
	* B	
;	B	MPY

4.4.5 Pass 4

Pass 4 fills in all forward address references. This cannot be done until the completion of all of Pass 3. Instead of performing a symbol-by-symbol scan of the program string to detect empty address fields, code generated for each buffer size record by Pass 3 is executed. This code calculates address expressions and inserts the results into their proper string positions. Relative segment entry points are then inserted into the linkage tables. The output segments are relocatable on the Illiac III without modification.

The IBAL translator is being programmed in PL/1 for execution on the IBM 360 at the University of Illinois. One guiding criterion being used is that the translator should be easily modifiable as the language undergoes further refinements. Another is that the transformation of this translator into a later one written in IBAL should be straightforward.

Pass one and parts of the general pass administrator necessary for testing it are coded and operating with only minor bugs remaining at this time. Target date for the completion of the entire translator is the end of January 1968, with the major part of the coding completed in early December 1967, followed by debugging and necessary modifications and extensions.

J. Schwebel

4.5 Compiler-Compiler

4.5.1 Creation of Floyd Productions From BNF Syntax

Using a study by J. Eickel and M. Paul on "The Parsing and Ambiguity problem for Chomsky Languages" (TH Munchen, Gericht Nr. 6409, August 1964) a system has been designed to produce a scanner from the Backus Naur Form definition of a programming language. This system which is described in DCS Report No. 237, has been flowcharted but not programmed.

The main purpose of this system is to produce a purposive parsing system with a left to right scan of an object string which reduces the string without having to 'back-up'. Consideration was restricted to Chomsky two type grammars and arbitrary finite bounds on the number of look-ahead or look-back symbols required. However the size of the subset of much languages for which the system will be effective is not yet clear without some practical experimentation on how the system works. Owing to the creation of large numbers of non-terminal symbols during the construction of the scanning system, the productions produced are not close to Floyd Productions. It has been hypothesised how something resembling Floyd Productions may be obtained; the original Munich group reputedly has obtained some results in this area - and this is currently the subject of an inquiry and an empirical study.

4.5.2 Prescanners

An attempt is being made to write a common prescan system for a number of languages. This has been programmed in PL/1 but unfamiliarity with the newly installed 360 system is causing some difficulties in getting this program to run correctly as yet.

The system is designed to accept free or fixed field card formats; to assemble and identify reserved words, identifiers, numbers and strings and other compound symbols; to place these in tables of symbols, numbers and strings, to output a string of internal numbers corresponding to the various elements of the program string, and to dump a listing of the symbol, constant, and string tables together with the respective internal numbers of each element.

A next pass is being flowcharted to scan the declaration and block syntax, and will arrange the identifiers in their block structure, together with their attributes.

A. W. McInnes

4.5.3 <u>FORTRAN IV Productions</u>

The FORTRAN IV syntax has been described in extended Backus Naur Form. The grammar should agree with that presented in the IBM manual:

> IBM System/360, FORTRAN IV Language
> IBM Form C28-6515-4.

The syntax is currently being transformed into Floyd productions, and is being typed onto cards.

R. W. Hecht

4.5.4 PL/1 Productions

The basic syntax of PL/1 was taken from the PL/1 Language Specifications (IBM Form C28-6571-3) and the PL/1 (F) Programmer's Guide (IBM Form C28-6594-1) and expressed in an extended Backus Naur Form. By special notational conventions in the PL/1 syntax it was indicated which parts of PL/1 are included in EPL, a subset language of PL/1 specified in the EPL Manual (BTL publication B0044) and the EPL Programmer's Guide (BTL publication B0062).

From this syntax in extended BNF the syntax of PL/1 in Floyd type productions is currently being written so as to provide the form of the syntax required by the Illiac III compiler-compiler. It is hoped that the syntax in extended BNF will also be helpful reference material for programmers using PL/1.

J. T. Engle

4.6 Illiac III Information System

4.6.1 Outline of the Information System

The proposed information system for use on the Illiac III will include four major parts:

Part I describes the data pool organization, and in particular the directory system; the rules for directory organization; how an item is represented in the data pool: the retention of names in the Term Encoding Table, tree structure specification in the Item List, the graph structure in the Link List; the segmentation of these tables; and other auxiliary tables.

Part II describes the data pool services, and consists of five sections. The first section describes how to search an item through the directories. Described are Inter-Directory Search and Intra-Directory Search. The second section involves item transmission: transferring data from one file to another file, or from one device to another device. Procedures to open and then close the file (and corresponding channels) are given. The third section describes the Inter-Directory Management. The fourth section covers Intra-Directory Management. The fifth section handles data acquisition and display. It includes man/machine communication, peripheral instrumentation communication and inter-machine communication.

Part III of the manual describes Task Supervision: including task translation, task scheduling, task execution, task audit and task acceptance testing.

Part IV has a list of manuals which will be available, the system documentation standards and a description of dialog-assisted use of the system.

Ping Koo

4.6.2 Data Pool Organization[1]

All data used by the Illiac III Information System will be kept in a common data base. Associated with every node of the data structure, there is an Item Class Code (ICC) assigned. Any item in the data base can be searched either by name or by Item Class Code. The item name and ICC will be stored in a directory using a method called the Binary Chop Pointer (BCP) which combines use of list and contiguous storage in core. In the BCP method, a binary chop method of access is used and items can be easily added or deleted from the list without disturbing the rest of the list.

In a BCP directory, for each entry two pointers are needed, a high pointer (HIP) and a low pointer (LOP).

For setting up the directory, the item is stored in continuous manner; the necessary thing to do is to set the appropriate pointer. The item will be compared against the entries in the directory; there are three possible conditions:

1. Equal to -- an item having the same name will be entered to the directory (probably with different ICC).

2. Less than -- the item is less than the entry being compared. If the LOP of that entry is empty, the LOP will be set which points to the location where the new item is to be stored; otherwise compare with the next entry.

3. Greater than -- the item is greater than the entry being compared. If the HIP of that entry is empty, the HIP will be set pointing to the location where the new item is to be stored; otherwise compare with the next entry.

Forming the directory and searching for a particular item in the directory involves a similar process. The only difference is that the LOP or HIP points to the next entry to be compared.

To delete an item from the directory, the first thing to do is to search the item, then give the space back to the free list. If the LOP (HIP) of this item is not empty, all points involved will be appropriately changed.

Ping Koo

[1] Method described here developed by David Gold and D. Austin Henderson, Jr.

4.6.3 Memory Segmentation

The storage algorithm described here, proposed by John Rohr, is an extension of the technique used in L^6 and described by K. C. Knowlton.[1]

The storage scheme, proposed for use on Illiac III, makes available blocks of memory in 9 different bay sizes - 1, 2, 4, 8, 16, 32, 64, 128 and 256 pages. (1 page = 256 bytes = 64 words). The smaller blocks may be obtained by successively splitting larger ones in half, and the larger blocks may be obtained by combining two or more adjacent small blocks together if the sum of their bay size is one of the 9 allowable bay sizes indicated above. One system register is provided for each bay size, and one keyword for each page. Keywords are kept in a keyword list.

The blocks are initially arranged in a doubly connected loop, of which one element is the system register. Each keyword contains the information about its bay size, the bay size of above block, a busy bit to indicate whether it is currently free or busy, one forward and one backward free list link. Every system register consists of a counter and a pointer. The counter contains the number of bays of this size that are currently free. The pointer points to the first keyword in the free list for this bay size. There is a linked free storage list for each bay size. The forward link of the last key word in the free list will link back to the system register of this bay size.

A block may be removed from its free list by making its predecessor and successor point to each other. However, when a block of particular bay size is required, using the system register associated with that bay size, a new bay will be taken from the location linked to the register (the system register will then point to the second key word in this linked free list). If there are no free bays of the required size, the block of the next larger size is obtained and split into two, one of its halves is returned to the free storage list of proper size, the other half will be assigned as the requested block and the busy bit will be set.

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[1] Knowlton, Kenneth C., "A Fast Storage Allocator" in Communication of ACM, Vol. 8, No. 2 (October 1965), pp. 623-625.

Blocks which become free will be inserted in the free list between the system register of that bay size and the first key word in the list by making the pointer of the system register linked to the keyword of this block and appropriately setting the four links involved. (The backward and forward links will be set so that the key word of this block will become the first key word in the free list and the original first key word will become the second key word in the free list).

The storage allocation procedure described above is applicable to any level of storage: core, disc, etc. The two parameters involved are the number of system registers and the number of key words needed which are dependent upon the total capacity of the storage and the bay sizes used. For the fast core, there are 1024 pages; therefore 9 system registers and 1024 key words will be needed.

Ping Koo

4.6.4 Storage Allocation Module

The following is a summary of the main topics presented in a paper on the storage allocation module.

1. Reasons for segmenting a program.
2. How segments are manipulated by the Illiac III hardware.
3. Tables for segment storage.
4. Delegation of Core.
5. Scheduling Module.
6. Interrelation of Scheduling and Storage Allocation Modules.

This summary article has been issued in Report No. 247, "Storage Allocation Module for a Time Sharing System", by Robert W. Hecht (Master's Thesis).

R. W. Hecht

4.7 The Web Language

4.7.1 Abstract of Reports

A formal description of the WEB language in Backus Naur Form (BNF) appears in DCS Report No. 232. The language arose from a need to describe separately, readily and concisely, the essential logical, geometrical and electrical characteristics of a contemporary digital processor in a form amenable to symbolic manipulation.

A Logic Description starts with irreducible packagable logic units (usually n-input NAND's or NOR's). Higher level logic blocks can then be described in terms of the defined units. One continues this process using block structure until the desired level of description is attained. A Housing Description (geometry) is given in terms of a bay containing racks of connectors with pins. A Module Description defines an irreducible physical unit in terms of its logical units, pins and their terminal connections in the module. The module contains the physical realization of the logic units that are to be housed. Lastly, an Assignment Description places a module in the housing in a particular rack and connector, and assigns each logic unit of each block its physical realization in a particular module. An illustrative example is given in DCS Report No. 243 by Hazelhurst, et.al.

Once a description has been completed one would like to make corrections or modifications not by physically modifying the original description but by appending it. This can be done by change orders added to the WEB syntax as defined in DCS Report No. 233 by Bond, et.al.

From such a set of descriptions, including any appended change orders, one can obtain a list of all pin-to-pin wiring, both intra- and inter-connector, necessary to complete the realization of the Logic Description. The length of wire needed for each pin-to-pin connection is obtained from the Housing Description.

WEB Reports:

No. 243, The WEB System, Part I: The Utilization of WEB by Hazelhurst,et.al, September 11, 1967.

No. 232, The WEB System, Part II: A Formal Description of the WEB Input Language by Bond, et.al., June 19, 1967.

No. 233, The WEB System, Part III: WEB Change Orders by Bond, et.al., June 19, 1967.

4.7.2 Implementation Strategy

The compiler-compiler technique will be used to implement WEB. This requires transforming the BNF syntax into Floyd Production Language (FPL). The FPL syntax can then be generated into a table of productions by a Syntax Loader. Once this is accomplished a WEB program describing a processor can be fed as a character input string to a Prescanner, where characters will be grouped into a symbol string, thereby allowing a syntactical analysis to be performed through use of the FPL table. A recognized production is passed on to its corresponding 'Execute' instructions. Through the use of 'Executes' the block structure is gradually recognized and stored for further processing.

Two passes of the process just described are necessary. On the first one the Logic Description is processed and a Packaging Skeleton listed. This listing is used to describe the Unit Assignment. The Housing, Module and Assignment Descriptions are processed during the second pass and combined with the output from the first pass. The complete integrated structure is then saved. From this structure wiring lists used for construction of the described processor and signal lists used for maintenance are produced. Wiring lists are currently obtained using a program implemented by W. D. Bond.

L. Dunn

4.8 Text Analysis and Synthesis

4.8.1 LEFT: Text Synthesis Language

A programming language known as LEFT (Language for Editing and Formatting Text) has been devised. The purpose of this language is to facilitate the automatic printing of free format text and graphics by computer. In contrast to most computer typesetting languages, LEFT resembles higher level programming languages in its flexibility and generality. Commands in the language are oriented toward specifying complex page formatting problems in a simple fashion. The input program consists of commands in LEFT for generating and updating text, together with text, which may be thought of as either string data or as analog (video) records.

An attempt has been made to differentiate between the medium-independent structure of text and the purely typographical or packaging description of text. Examples of the former are chapter, illustration; examples of the latter are line and page which have no intrinsic meaning in relation to the semantics of the text. Several features cannot adequately be represented in just one of the two categories, e.g. underlining.

The separation of these two descriptions allows an input document to be scanned, stripped of its typographical content and to be replaced by its logical description. The logical description can be searched by a query language to establish its context and then outputted in alternate formats as specified by choice of style-manual. (Here, a style manual can be considered a formatting program in LEFT). Given the logical description, LEFT may be thought of as a mapping which generates the typographical description.

For the logical description, a structured information storage scheme known as LSD (Logical Structure of a Document) has been proposed.

The implementation of LEFT in software and hardware is taking place. The language will be used with the videograph printer of Illiac III, a high speed printer which can output free form text, graphs and pictures concurrently. A formal report of the language will be found in S.J. Flowerdew's File No. 737, "A Language for Editing and Formatting Text", September 29,1967.

S. J. Flowerdew

4.8.2 Information Search Language

An assembly-type programming language designed for manipulation of character data in the CDC 1604 has been in development since October of 1966. The objective of the language is to provide an information-retrieval experimenter a simple means of extracting, editing and reorganizing character data.

The principal instruction is SEARCH which searches memory for a match to a specified data string (including "don't care" markers), similar to operations in SNOBOL or COMIT. The SEARCH instruction returns a marker indicating success or failure of the attempted match and the addresses in the data string over which the match occurred (if successful). Appropriate use of SEARCH and test instructions (Fortran IF-type) allows one to determine the existence of any set of data strings S1, S2,... joined by any prescribed Boolean operators. Results of searches may be written as records on an output magnetic tape or printed or both.

During the second quarter of 1967 the information search language was developed into a working system. The final version has a repertoire of 21 instructions as opposed to the 14 originally envisioned, the additional instructions adding to the flexibility of the system.

This Information Search Language was used to write several "service" routines to be used in getting the data base into a workable form. Among these are such functions as listing data tapes, copying data tapes, and packing the data into a condensed form. Also a syntax checking routine was written using this language to check the data being prepared for experiments which will use the language. Thus the Information Search Language (ISL) was a functioning system by June of this year and had been used to facilitate preparation of the actual data it was designed to handle.

At this point, it seemed pertinent to attempt to develop an interactive system using a display scope and typewriter station, to search for requests entered at the typewriter. Work was begun immediately to implement such a system. However, the ISL system as it then existed did not lend itself well to such a large programming problem requiring extensive subroutine structures and a variety of output capabilities. The computer programming group of the Coordinated Science Laboratory was in the final stages of developing a programming system (ILLAR) for use on the CDC 1604 computer, which makes very

convenient all of the features which were required to overcome the short-comings of ISL as it existed at this point.

During the summer months the information search language has been embedded in the ILLAR programming system. What now exists is a much more powerful programming tool. In this system, the user may write a program with only the 21 ISL instructions-- but in addition he may use any of the ILLAR-system routines, any machine language instructions, and also may make use of recursive macros, subroutines called by arguments, etc., which facilitates development of his own library of subroutines.

Concurrently with the implementation of this system, programs were developed to display the data on the graphic unit that recently has been developed at the Coordinated Science Laboratory. These programs are in the form of subroutines to be used by the interaction program. By the end of August, this display capability was written into the system and work was begun on the actual interaction program. Certain portions of this program were already working at the end of August. Also by this time the "service" routines were re-written in the new system. The intention is to develop an elementary monitor package to facilitate copying, listing, translating from IBM 1401, packing the data, and checking the syntax of the data. All of these programs are working. In the immediate future we expect to receive from Control Data Corporation a 1604 sort routine, which is needed to facilitate completion of key-word in context programs, word-frequency counts, and the construction of a key-word dictionary.

K. Kelley

S. Ray

4.9 Outline of Illiac III Computer System

The section numbers of the outline below correspond to section headings of this Progress Report.

4.10 Central System

- 4.10.1 Taxicrinic Processors
- 4.10.2 Fast Core Storage Modules
- 4.10.3 Arithmetic Units
- 4.10.4 Interrupt Unit
- 4.10.5 Pattern Articulation Unit
- 4.10.6 Exchange Net
- 4.10.7 Status of the Main Frame Assembly

4.11 I/O System

- 4.11.1 I/O Processors
- 4.11.2 Channel Interface Units

4.12 Peripheral System

- 4.12.1 Secondary Storage System
  - 4.12.1.1 Magnetic Tape System
- 4.12.2 Scan/Display System
  - 4.12.2.1 Scan/Display Control
  - 4.12.2.2 Scanner/Monitor Center
  - 4.12.2.3 Scan Converters
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  - 4.12.2.5 Videograph Printer
  - 4.12.2.6 Remote Video Consoles
  - 4.12.2.7 Video Storage
  - 4.12.2.8 Microimage Storage
  - 4.12.2.9 Specifications for the Microfiche Library

- 4.12.3 Intermachine Link to Illinet (IBM 360)
- 4.12.4 Low Speed Terminal Network
    - 4.12.4.1 Low Speed Communications Net
    - 4.12.4.2 Low Speed Buffers
    - 4.12.4.3 Low Speed Terminals
        - 4.12.4.3.1 Monitor Selective Typewriters (5)
        - 4.12.4.3.2 Monitor Magnetic Tape Module (5)
        - 4.12.4.3.3 Mod 33 ASR Teletype Sets
        - 4.12.4.3.4 Analog Instruments

4.13 Power Distribution

- 4.13.1 Primary DC Power Supplies
- 4.13.2 Power Distribution System
- 4.13.3 AC Power Distribution System

4.14 Unassigned Equipment Pool

- 4.14.1 Circuit Card Inventory
- 4.14.2 Test Equipment Inventory: Commercial
- 4.14.3 Test Equipment Inventory: Custom-Designed

4.15 Documentation

- 4.15.1 Engineering Manual
- 4.15.2 Circuit Books
- 4.15.3 Logic Book
- 4.15.4 Wiring Tables
- 4.15.5 Opto/Mech. Design

4.16 Circuit Research and Development

- 4.16.1 Card Testing
- 4.16.2 Hand Wheel Digitizers

4.10 Central System

4.10.1 Taxicrinic Processors

4.10.1.1 Logic Design

Flowcharts for the Taxicrinic Processor control logic have been largely completed. These include:

a. Memory Access Sequence

b. Operand Stack Control Sequences

c. PAU Instruction Fetching Sequence

d. Primitive Instruction Sequences

e. Imprimitive Instruction Sequences

f. Multi-Cycle Sequences

The flowcharts for the arithmetic instructions and for the supervisory instructions have not been completed. Also on the basis of simulation studies the imprimitive and multi-cycle sequences may need extensive revision to incorporate recent simplifications in these instructions. The remaining control sequence flow charts are detailed down to the micro-operation level and are accompanied by detailed written descriptions.

Currently the existing logic is being carefully examined to correct logical design errors and to add additional logic which will be needed by the expanded order code. It appears at the present time that considerably more room will be needed for the TP control logic than was originally anticipated.

4.10.1.2 Documentation

A complete manual of the Taxicrinic Processor has now reached the first rough draft stage. It is being written to specify the complete hardware form of the Taxicrinic Processors. When completed this manual will contain detailed descriptions of every part of the TP logic along with all necessary tables, illustrations, etc. A complete signal name directory will also be included.

A preliminary IBM card file of all of the signal names in the Taxicrinic Processors has been completed.

4.10.1.3 Hardware and Wiring

As a result of the fire, the registers and address construction logic of the taxicrinic processors, previously wired, will have to be rewired. Changes suggested above will be incorporated at this time.

B. J. Nordmann

4.10.2 Fast Core Storage Modules

The two 16K, 80 bit/word "fast" core memories are presently under construction at Fabritek, Inc. (Edina, Minnesota). The first of the two identical units was in the midst of check-out in mid-October when the final design review was conducted.

It appears virtually certain that the first memory will be completed and delivered circa December 15, 1967. The second unit is scheduled for delivery one month later.

There is little doubt that all primary specifications will be satisfied, leaving (we expect) only the usual long-term test and diagnosis required to tune a first-of-a-kind memory to fully acceptable error rates under actual operating conditions.

S. R. Ray

4.10.3 Arithmetic Units

The development of the arithmetic units may be treated in three phases. The first phase, conducted largely during the 1965-66 academic year, dealt with specifying the AU orders and algorithms and techniques for realizing them. Work during this first phase included searching of the literature on AU design and consultation with Professor J. E. Robertson on digital arithmetic methods. The results of this phase of work was 1) a detailed definition of the AU orders and treatment of exceptional conditions, 2) specifications of the technique for communication of the AU with the other parts of the system, and 3) a first-order specification of the main algorithms used in the execution of AU orders.

The second phase of AU design has been conducted during the past academic year, 1966-67, through its present. This phase is dedicated to the refinement of the specifications resulting from phase one and the transfer of these studies into logic.

The first part of this second phase was devoted to an exploration of the most novel aspects of the Illiac III Arithmetic Units: the so-called, Signed-Digit Subtractors (SDS) and, the division algorithm. The signed-digit subtractor is a member of the class of add/subtractors which postpone carry/borrow until a terminal step. Such a device is essential for high-speed multiplication. Several designs were studied; one was eventually selected and implemented on a special logic card, the 1018-275. The operation, the SDS, overflow detection and the assimilation of the result to conventional binary form were simulated with MAD on the IBM 7094.

Division in an Illiac III AU will be accomplished with an advanced technique suggested by J. E. Robertson. The main property of this technique is that quotient bits may be formed by inspection of only the first few bits of the divisor and the partial remainder. The binary case of this class of techniques, SRT Division, has been widely used. In Illiac III, however, this technique is extended to radix 256. The results of this study on the division algorithm may be found in DCS Report No. 230, "The Theory and Implementation of SRT Division", by Daniel E. Atkins. The algorithm was also simulated with MAD.

Another major accomplishment of phase two was the selection of a register, add/subtractor, and inter-register gating configuration which was compatible with all operations. Of course, this step required more careful specification of the flow of data through the unit for each AU order.

With a block diagram of the registers, main gates, and functional sub-blocks (e.g. quotient selector, multiplier recoder), it was next possible to begin specification of the logic hardware to be used. At present, the logic diagrams are largely complete for the registers and main gating and specified, although not drawn in detail, for the functional sub-blocks. The specification of the control logic is now the prime task remaining in phase two.

An essential aspect of the design, construction, and eventual maintain of a complex device such as AU is good documentation. Toward this goal, a manual format has been carefully outlined. The manual is presently being edited and updated with expectations of publishing the first version in the immediate future. The AU will also require the support of well-trained technicians. Anticipating this fact, a technician (L. L. Byers) has been assigned to the AU development task and is presently assisting in the preparation of the logic diagrams. By participating in the design and development of the AU he will be well equipped to play a vital role in its construction, check-out, and maintenance. The simulation of parts of the AU has proved to be a valuable and reassuring design tool. It has been decided, therefore, to expand the earlier simulation and to prepare a complete simulation of the arithmetic unit using PL/1 with the IBM 360/50 computer. This simulation is presently being supported by a professional programmer. It will serve as dynamic documentation and as a tool in generating effective diagnostic routines for the actual arithmetic units.

Phase three will consist of generating logic packaging specifications, assembly and initial checkout of the AU's. It will also requre the design and construction of a text device for communicating with an AU while it is disconnected from the Illiac III Exchange Net.

Although the specification of control logic is still a large task remaining to be done in phase two, it is possible to begin phase three.

Shortly work will begin on the transformation of the logic diagrams for the registers and main gates into packaging diagrams and wiring tables.

Present planning calls for the completion of phase two about February 1968 and to have one AU operational within the fall of 1968.

D. E. Atkins

4.10.4 Interrupt Unit

Any interprocessor communication or clock operation must be processed and forwarded by the Interrupt Unit (IU). No instruction is executed completely within the IU: at least one processor is always involved.

There are three types of interrupts: local, distant and programmed. Local and distant interrupts are caused by hardware and programmed interrupts occur when a "interrupt and transfer" command is executed.

4.10.4.1 Local

Local interrupts are generated within a processor and are handled completely within the processor in which the interrupt condition occurs. Examples of this class of interrupt include illegal operation request, arithmetic overflow, violation of memory protect and so forth. This class of interrupts is not handled through the interrupt processor.

A processor solicits the assistance of the Interrupt Unit through the Exchange Net in the same manner as for any other unit. For IØP-to-TP interrupts, a register in the IU stores the transfer address. For TP-to-TP interrupts, the address is specified by the instruction or wired-in-addresses. An interrupted IØP receives a full word command. An interrupted TP receives a fullword address and a double word of status information which is pushed into the ØS.

The interrupt control word specifies the disposition as well as the source and nature of the interrupt. The format of the interrupt control word is given below.

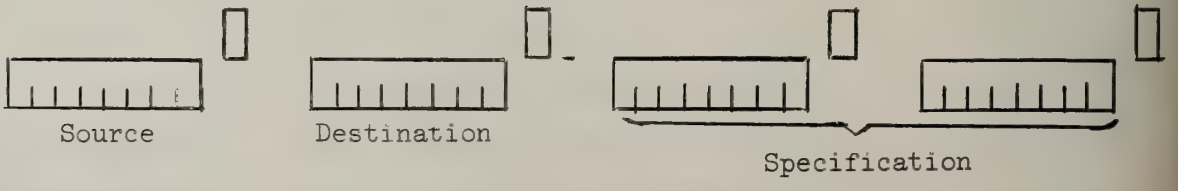

Figure 2.5.1.2 Interrupt Control Word

The destination byte and the source byte specify the processor to be interrupted and the terminal causing the interrupt, respectively.

4.10.4.2 Programmed

Programmed interrupts are caused by the execution of an "interrupt and transfer" command in a processor. If the processor is in the user mode (protected instructions forbidden), this instruction invokes the supervisor and is a local interrupt. If the processor is in the supervisor mode, (i.e., has a job with a priority value higher than 1, then if another processor is to be interrupted, a distant interrupt will occur.

4.10.4.3 Design Status

Interrupt Unit design is in a preliminary status. A preliminary instruction repertoire has been specified, but final design awaits specification of the multiprocessor operating system for Illiac III.

4.10.5 Pattern Articulation Unit

Progress on the Pattern Articulation Unit will be described in four parts: 1) the PAU Control, 2) Iterative Array, 3) Transfer Memory and 4) Display System.

4.10.5.1 PAU Control

The order code for the PAU has been defined and consists of 31 orders. These orders should be sufficiently general to allow full use of the capabilities of the PAU. All data formats are consistent with the scanner data formats. The Illiac III Programming Manual will have a complete discussion of the PAU order code so it is not reproduced here.

The design of the control has begun again. The control will be of the pseudo-asynchronous type to allow the Iterative Array to operate at its highest speed, since it is assumed that most PAU operations will take place in the Iterative Array.

All previous work on the control is being re-examined in light of the new order code. It will be possible to use several sections which have already been designed.

4.10.5.2 Iterative Array

The Iterative Array was wired and ready for checkout before the fire. It was decided that the Array should be rewired after the fire.

The wiring has been completely specified in File No. 731. Several changes in notation were made. The planes are now labeled P0 through P7, the STACKING operation has been changed to TALLYING, and the neighbor gates and neighbors have been renumbered according to the following convention:

6	7	8
5	0	1
4	3	2

The stalactite tester has been rewired to enable planar operation, wrap-around in either direction or wrap-around in both directions. This will

allow the tester to be operated manually and to be used as a small iterative array to check control sequences for the control. Stalactite testing was restarted after the fire.* At the present time 1039 normal stalactites and 27 border stalactites have been tested. The array needs 1024 normal cards and 132 border cards.

Thus it is anticipated that checkout can commence as soon as the array is rewired, and that there will not be a delay due to stalactite testing.

4.10.5.3 Transfer Memory

The transfer memory was completely specified and wired. The memory operations in the short word submode were completely checked out. The operations in the long-word submode were partially checked out. All that was necessary to finish the checkout was the completion of the m-plane array.

This, however, was not completed before the fire, and after the fire the decision was made to rebuild the transfer memory from scratch.

A new method of mounting the core planes has been designed which should offer them more protection and decrease the mean time before failure. A new connector has been devised which has wider etch lines and fingers. Also these connectors may be wired with stranded wire as opposed to the solid wire previously used. This should reduce the danger of wires breaking at the connector.

All changes made in the checkout of the transfer memory have been incorporated in the new wiring lists. The printed circuit boards have been cleaned and have undergone preliminary testing. The new wiring job will commence when the necessary printed circuit board connectors arrive.

4.10.5.4 Display System

The old PAU Display System consisted of 1156 light bulbs with associated indicator drivers and cabling. This unit was located above the engineering test panel. The system was checked out.

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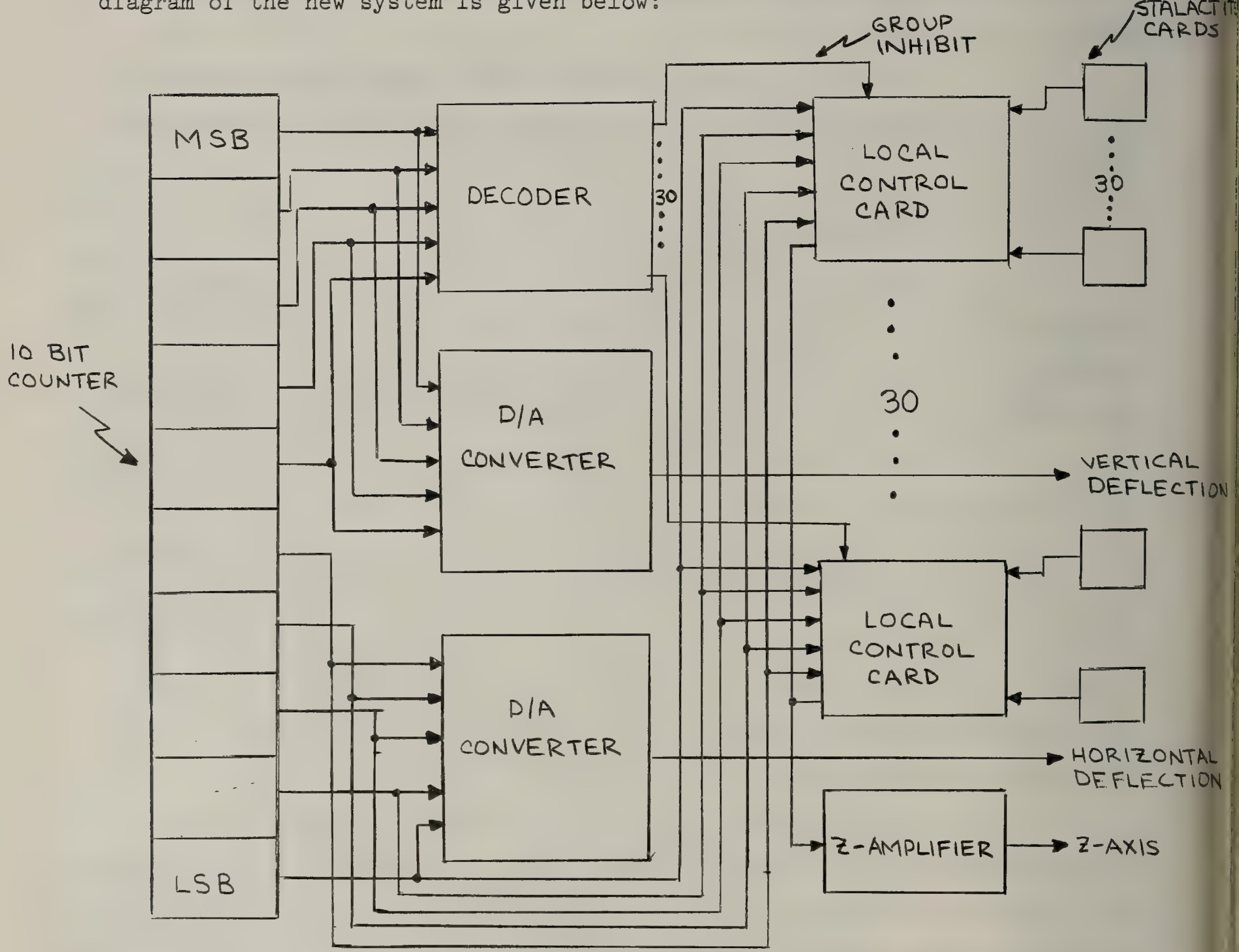
*A new test was added in order to check for any propagating errors in the stalactite operation. The old test did not check planar transfers.

Fortunately the fire destroyed the old system and a new, vastly more simple and reliable, system has been designed. The block diagram of the new system is given below:



The local control cards select one stalactite card at a time and put the contents of the stalactite on a common bus. This bus modulates the z-axis of a CRT. The horizontal and vertical sweeps are derived from simple ladder-type D-A converters. Thus the output is a 32 x 32 raster of points on the scope. The principle features of the system are that it is cheap in the area of power consumption, that only three coaxial cables carrying analog signals have to be connected to the engineering console, instead of the 1700 wires used in the old system, and the system should be more reliable since it uses no bulbs and associated drivers.

R. T. Borovec

4.10.6 Exchange Net

At the present time the intermediate logic drawings for the Exchange Net have been completed. The card layouts have been partially completed and loading, fanout and timing problems are being double-checked. The following DCL Report No. 231, "Communication Net of Modular Processors for a Multiprocessor Computer", by S. K. Chan, provides a detailed functional description of the operation of the Exchange Net.

B. J. Nordmann

4.10.7 Status of Mainframe Assembly

September 30, 1967, through March 1967 (Illiac III fire)

1. Structural part of mainframe completed.
2. Structural part of mainframe positioned, leveled and secured to floor.
3. All card racks assembled and installed.
4. Ground buss system was half completed.
5. Capacitor banks were installed.
6. Half of the Modine bars (bars that support local voltage regulators) were fabricated and installed.
7. Modine regulator fabrication complete.

March 4, 1967, through September 30, 1967 (Illiac III fire)

1. Structural part of mainframe cleaned and repainted.
2. Structural part of mainframe relocated, leveled, and secured to floor.
3. Wings (that part of the mainframe structure that contains card racks) modified to facilitate air-conditioning of cards.
4. Installed ground buss system and secured it to the floor.
5. Installed another central section for the addition of two new wings.
6. Installed capacitor banks.
7. Removed fire damaged card guides, connectors and power buss bars (bars service card racks).
8. Assembled new card racks to the extent that they can accept new connectors (on order).
9. Cleaned power buss bars and began modification to the extent that they can accept new conductors (on order).
10. Local voltage regulators (fire damaged) renovated.
11. Proposed false floor and air-conditioning technique for mainframe area.
12. Removed fire damaged hardware from Modine bars (bars used to support local voltage regulators).
13. Reassembled Modine bars to the extent that they can accept new connectors (on order).
14. Fabricated the remainder of the Modine bars.

P. Krabbe

4.11 Input/Output System

The Illiac III system contains two identical Input/Output Processors which directly control all I/O operations. The vast majority of I/O operations involve the transfer of information between main storage (fast core) and peripheral I/O devices. I/O devices include secondary storage media (e.g., magnetic tapes and disks),scan/display equipment and low speed terminals (teletypes, etc.)

Each IOP is a high-speed communications center which can direct I/O operations on up to 8 I/O channels concurrently. A channel* is defined as a physical information transmission path (data and control lines) linking an IOP to a group of I/O devices. Each channel is connected to the IOP via a Channel Interface Unit (CIU). The CIU acts as a buffer between the very fast IOP and the relatively slow I/O devices. The CIU relieves the IOP of the routine data packing/unpacking operations and response signal generation associated with data transfer.

I/O channels are terminated by one or more I/O Device Controllers (DC's). One CU may control several similar I/O devices (e.g., a bank of magnetic tape units is typically served by a common tape DC).

The connection between a CIU and the DC's on the same channel is called the I/O Interface. This constitutes the main I/O data transmission path; it may connect very remote DC's to the main computer. The I/O interface in the Illiac III System is a slightly extended version of the I/O interface employed in the IBM System/360; this interface is hereafter called the X/360 (for extended/360) interface. The X/360 interface is fully compatible with the standard IBM System which has been widely adopted by I/O equipment manufacturers.

A maximum of 256 independently addressable I/O devices can be attached to an I/O channel. Each I/O device may be considered as being connected to its IOP by a Subchannel. Thus there are essentially 16 x 256 = 4096 subchannels available for the connection of I/O devices.

*The word "channel" is also used to refer to an I/O Processor, e.g., in IBM System/360 literature. The IOP of the Illiac III approximates a "Multiplexor Channel" in IBM terminology.

4.11.1 I/O Processor

The functional organization of the I/O Processor is based upon the I/O model tested in the Master's thesis of Cederquist. Appending to this model a comprehensive command code of both I/O device-dependent commands (READ, WRITE, SENSE, etc.) and I/O device - independent commands (for command/data bookkeeping) occupied the better part of the summer (John Hayes).

Preliminary control flow charts are prepared during the summer. This flow serves as the basis of the IOP simulation, discussed above. In the course of the simulation some oversights of logic, as well as simplifications, have been found and provisions to modify the IOP design accordingly have been made.

Basic register and gating paths for the IOP are relatively firm, and many parts of the logic follow directly the TP design -- e.g. main storage addressing. However no control logic hardware has been laid out at this time, and will not be until first quarter 1968.

4.11.2 Channel Interface Units

The basic register arrangement of the Channel Interface Unit was settled during the summer 1967. A detailed simulation of the sequencing logic of the unit was written in SNOBOL and tested by John Hayes. At this stage a preliminary manual for the CIU, defining the control sequences, was written.

More recently design emphasis has shifted to implementing the control logic in hardware. Completion of the logical design of the Channel Interface Unit is projected for December 1967.

B. H. McCormick

4.12 Peripheral System

This system is divided into several subareas which are of approximately 60% DCL design and 40% commercial design. The status of the various subassemblies is as follows:

4.12.1 Secondary Storage System

4.12.1.1 Magnetic Tape System

An Ampex tape system, consisting of eight tape transports, two data controllers, one master system control unit, and one system exercizer (test unit) was installed in Room 280 in the fall of 1966. The inter-unit cabling was connected and preliminary tests were performed on these units during the winter of 1966. There were many discrepancies noted to exist in the system at this time and corrective procedures were initiated. The twelve units were considerably damaged by heat, smoke, and residue from the subsequent fire fighting efforts. Clean-up of the fire damage was tedious and not 100% effective. Five of the eight tape transports are still in-operative and further testing will be performed on all the units to establish their reliability.

J. V. Wenta

4.12.2 Scan/Display System

4.12.2.1 Scan/Display Control

The original order code has been extensively modified to allow more flexibility in the parameters of the operating modes and to eliminate certain awkward programming features. The updated manual now contains all parameters and formats used to initiate an Illiac III Scan/Display order in any of the four modes:

1. Coordinate
2. Raster
3. Video
4. Incremental

R. M. Lansford

4.12.2.2 Scanner/Monitor Center

4.12.2.2.1 Electronic Design and Fabrication

The four scanner and five monitor centers were cleaned up and repaired due to the heat and smoke damage sustained during the fire. The analog section of one monitor has been completed and tested and the analog section of the 70 mm. scanner is about 90% complete. This unit will be tested in the near future. The wiring of the remaining monitors and scanners is now in progress and should be ready for testing about January of 1968.

4.12.2.2.2 Optical/Mechanical Design and Fabrication Status

Two 70 mm. scanners are in the final stages of work. All optics are in. One unit is undergoing mechanical and optical test and awaits motors, a C.R.T., and photomultipliers. One pneumatic unit to drive the film transport has been installed and works well. The second unit is in final assembly after fire damage repairs. No significant re-design is foreseen.

Two 46 mm. transports are in the same status as above except that they are as yet unmounted. Again, all optics are in house. All pneumatic parts for all of the film transports are in house awaiting assembly. One 70 mm. transport will be thoroughly tested and debugged for possible changes before assembling and testing the remaining units. This will guard agains possible needless teardown and alteration.

The 35 mm. scanners are in a fair stage of completion with the following comments. One 35 mm. camera was fire damaged, but both must be sent to the manufacturer for modification to full frame pull-down. All auxilliary optics are complete but some machinizing remains. Camera mounts are completed. The 16 mm. cameras are in and the mounts are on order in the machine shop. Little work remains to be done on these units. We are awaiting delivery of two microfiche transport mechanisms from Bell & Howell. These require design modifications, extensive in nature, which cannot be accomplished

until the transports are on hand. Additional optical design is needed to adapt the fiche transports to our scanners. The 35 mm. and 16 mm. portions of this scanner are ready for use but the microfiche units may be delayed six months.

The microscope stage scanners are ready for mounting design and illumination optics design. While the general design of the units is complete, and the microscopes and one stage are in house, the detail design and construction remains to be done. The second stage is on order from the Physics Department and should be ready early next year.

In summary, the 70 mm., 46 mm., and 35-16 mm. units are essentially complete insofar as mechanics and optics are concerned. The microscope units require more design work. One 70 mm. scanner will be ready to run for test purposes as soon as the electro-optics have been tied in.

R. G. Martin
R. C. Amendola

4.12.2.3 Scan Converters

One or more scan converters will be needed to assist graphic data I/O from the Video Communications Net. In the past, there has been a marked lack of equipment which would handle the 1536 television lines anticipated for our system. The problem had been in building a storage tube with sufficient resolution to store the mass of data points and read them back out at the conversion rate needed. The control circuitry posed no great problem, the tube itself was the obstacle. In early 1966, Raytheon introduced its model 1527 storage tube which was capable of 1800 television lines across its diameter which indicated that it could marginally handle our 1536 lines.

Image Instruments of Waltham, Massachusetts promptly incorporated this tube into an "Electrostore" unit and proposed an Electrostore, programmer, sync separator, and two sweep generators for our older 1029 line system at $28,350 for one package. No action was taken on the proposal as detailed specification of this unit depended critically on the high resolution closed circuit television cameras finally selected for the network. Since then we have gone to a 1536 line system, and have not further explored scan converters of this type in terms of the present resolution requirement and altered scan rate.

While there are one or two more companies producing high resolution scan converters of the type required by DCS, they will doubtless have to modify existing equipment or design anew in order to meet the very high resolution requirement. It is fairly clear that we will need two scan converters capable of storing high quality 1536 line video images in the near future.

R. C. Amendola

4.12.2.4 Video Communications Net

An extensive and flexible Video Communications Net is planned for Illiac III. Initially, this Net is to consist of six remote closed circuit television consoles each incorporating a "fast" and a "slow" monitor tube. Provided with these primary display devices is a microfiche viewer (incorporated in the console), an ASR Mod 33 teletype unit, one or more cursor controls, and other ancillary equipment.

Cameras may be incorporated optionally at the remote terminal. All communication is via fast scan 1536 line 15 field per second, slow scan 1536 line 1.25 field per second television; and digital lines to handle moderate rate small computer or instrument data and teletype. All data is to go by high quality coaxial cable. A switching matrix to handle various functions has yet to be decided upon, but several are available. A number of cables are found to be suitable to our needs. There remains their selection and permission to run the wire through existing duct facilities or to trench. The Network plan remains as outlined in File Nos. 706 and 728 except for the changes in television rates noted above. Bids on the camera and monitor equipment are back from Ampex Corporation, and it appears that they are willing to meet our specifications. The contract with Ampex is now awaiting Chicago Operations Office (AEC) approval.

R. C. Amendola

4.12.2.5 Videograph Printer

An A. B. Dick Videograph Printer has been purchased under the contract and will be delivered November 8, 1967. The printer has a 1536 television line capability and will take our video input and output 8½x11 inch hard copy at a rate of 14 inches per second ready for use. The printer thus runs at our 1.25 frames per second slow scan rate and is fully compatible with the video communications net. The print quality is high with a capability (with its companion character generator) of producing 132 characters in the 8½ inch width. With five levels of grey available, the printer will produce hard copy of virtually any video frame sent over our Net lines at the proper rate. A trip to the factory by Wenta and Amendola served to ascertain the quality and readiness of the printer.

A. B. Dick will supply by the end of the year a much modified model 990 character generator to drive the printer for standard text. The character development is by means of stroke generation inserted into the video train as a 9x12 matrix. It will write a typical character into the video line in 3.2 microseconds packing 132 characters in the page width. The generator is clock driven and will drive the printer at full speed or about 12,000 characters per second. During the inspection trip, it was determined that the Videograph Printer is ready to be shipped but that the hard wire changes to the character generator had not been started. However, the generator should be ready by the end of the year as promised.

R. C. Amendola

4.12.2.6 Remote Video Consoles

As discussed in the previous section, the cameras and monitors for the Video Communications Net will be supplied under subcontract to Ampex Corporation. There are two identical monitors for each console, one for fast scan, one for slow. The only real difference between the tubes is that one has the normal fast decay P-4 type phosphor for running at the 15 frame per second speed and the other has P-26 slow decay phosphor to accommodate the 1.25 frame per second speed. The tubes will be 17 inch nominal diagonal units with an 8½x11 inch usable screen area. They will operate with the face 60° to 75° to the horizontal for comfortable viewing and have the long page dimension up-down. The tubes will sit side-by-side in the console along with the microfiche viewer.

The console will be normal desk height with the tubes and fiche viewer above on a slanted face. The frame and most of the non-equipment mounting panels of the console will be of furniture-grade wood with formica covered panels. This should lead to a quiet, comfortable, sturdy, and pleasant piece of equipment at reasonable cost which, when fireproofed, will also be quite safe.

Sufficient design studies have been done to allow construction of at least one console for checking and test purposes. When this console is completed, and changes incorporated, the remainder of the consoles will be built. Included in the console are spaces and mountings for the monitors and associated controls, the microfiche reader, cursor controls, instrument I/O, and sufficient writing area and storage for a user to be comfortable and realize the maximum utility of the terminal.

R. C. Amendola

4.12.2.7 Video Storage

For general image processing, and particularly for text editing and reformatting, it is expedient to have a data storage device which can store entire segments of the video image. These segments of the input image are most inexpensively stored directly in analog form on a disk. In this way a photo-montage can be generated at the output display device (videograph printer, monitor, etc.) with minimal conversion computational cost.

For this purpose various disk stores for high resolution closed circuit television have been investigated, for both the 1.25 and the 15 frames per second rates, and matched for the resolution requirements of the video communication net. In particular it now appears that at least one manufacturer, Data Disc Inc., can satisfy the resolution requirements for the fast scan rate, and probably also for the slow scan rate for the high resolution image at 0.8 seconds/frame. However this latter storage unit would require some developmental engineering. A contract for prototype discs is tied up for lack of funds -- reflecting the higher cost than anticipated for the CCTV camera chains of the video communications net.

B. H. McCormick

4.12.2.8 Microimage Storage

During the past year, many and varied plans and purchases have emerged concerning microimage technology and its application to Illiac III. Since we did not have full facilities for design and construction of microimaging devices, and since the advantages of a massive photographic data file for machine access appeared distinctly appealing for Illiac III, steps were taken to investigate various microforms in terms of suitability for machine use. It became obvious that the microfiche was the first logical step toward the storage of massed visual data in an editable form. The COSATI* microfiche can contain a maximum of 72 8½x11 inch page forms on a film sheet approximately 4x6 inches. These images are arranged in a 6x12 matrix. The cards are very good for moderate data storage and manual filing. However, while these cards are ideal for manual data files and automatic retrieval of a hundred cards or so, when we began to investigate really large data bases in terms of very high speed (1-5 second) access and display by remote closed circuit television, it became obvious that there was just too much physical mass to allow an adequately responsive system.

For instance, 10^5 pages of information would occupy between 1429 and 2000 film cards or fiche. In order to access and display such fiche at the rates Illiac III will handle, a great deal of engineering and money would have to be spent, mostly on prototypes. When one increases this amount of data by three orders of magnitude to meet the 10^5 books of 500 pages each, the ultimate design goal of the project, the whole idea of fiche rapidly falls apart. Either we had to reduce the mass of the image storage medium, or we had to go to higher packing densities, which meant smaller images. We have since settled on a reduction of about 9:1 over the COASATI image giving us a total reduction of 162:1. Now for 10^5 pages we can get by with 20 minifiche each with 5000 pages on them. A proposal is being prepared by Fairchild-Hiller Division of Republic Aviation for the equipment and/or service to reduce images to this packing density.

*Committee on Scientific and Technical Data

Ancillary devices must be built either to utilize the Fairchild-Hiller system or to produce minifiche from our own microfiche file. Such devices have had a preliminary airing and appear feasible. Only one other company, NCR, offers an ultramicro-image system, but the company is unwilling to sell any part of its facilities which, incidentally, cannot be used as separate units since a large precise photochromic facility under strict environmental control is necessary. Fairchild-Hiller is quite willing to sell or lease any of its equipment or to offer complete or partial master and contact copy services. Feasibility studies are therefor being conducted in terms of the capabilities of this company.As a backup we are carrying out preliminary plans should we have to independently subcontract the necessary final reduction and re-formatting cameras.

R. C. Amendola

4.12.2.9 Specifications for the Microfiche Library

During the past year, a complete microfiche production facility has been assembled under the contract. We now have an excellent camera facility and a diazo duplication system capable of producing very high quality contact copies of our master negatives. We are awaiting delivery of a film processor, and with its arrival, will be ready to go into production. A competent operator can photograph at a rate of about 500 pages per hour.

With the exception of filing and storage units (which are readily available), we can now begin photography of a distinctive source document library for reference and machine use. Initial plans are for a 10^5 page library of diverse scientific information with enough format variety to allow investigation of computer reformatting for microimage mass storage. Such experiments are to be carried out on our microfiche scanning and photographing units to be built into the basic 35 mm. scanner.

There exists an additional possibility of adapting our microfiche camera to the photography of a high resolution C.R.T. for the semi-automatic high speed production of quality microfiche. Such a device could be built

much more economically than purchasing a CRT to microfiche machine now available. Under machine control, a very flexible device would result without jeopardizing the camera's ability to do straightforward fiche photography. At this time budget and engineering pesonnel constraints preclude exploiting this possibility.

In any case, the 10^5 page microfiche library is essential to form an initial reference library which could serve as a first reduction editable master for incorporation into our massed microimage storage for fast machine access.

R. C. Amendola

4.12.3 Low Speed Terminal Network

4.12.3.1 Low Speed Communications Net

Devices termed 'low speed' include ASR 33 Teletype consoles, IBM Selectric typewriters and LINC-type magnetic tape modules at the monitors, anticipated analog instruments, and numerous remote devices for instrument process control (remote television camera pan, tilt, zoom, etc.).

These terminal devices communicate with Illiac III through two Low Speed Buffers, each capable of handling 14 terminal devices. (See Section 4.12.4.2). The communication channels can be Bell Telephone Lines (both analog and digital Data-phone connections), direct wire links to local teletype consoles, or over multiple twisted-pair cables laid in conjunction with the Video Communications Net. In this latter case, group switching matrices, tentatively six in number, will be located at various buildings throughout the campus. Each matrix, controlled by the central computer, will be able to handle traffic from and to several local terminals by multiplexing over the low speed trunk cable package. This arrangement allows us to distribute signals very economically with a speed sufficient to allow full multiplexing of a number of devices with no significant waiting period by the user. The cabling and switching devices are readily available and suit our needs. Occasional compensation amplifiers will be provided where necessary to insure clean, hard signals.

Each remote console will have the following low data rate equipment: a teletypewriter, a small programmable keyboard, a machine control patch panel, and an instrument interface plus cursor control. Thus five or more signal lines must be provided for each console to accommodate low speed equipment.

4.12.3.2 Low Speed Buffers

The design of this section is almost 100% complete and has been divided into two major groups.

1. Low Speed Buffer Control - The design is complete and a prototype has been started.
2. Console Memory - The prototype of the magnetic module for the low speed buffers was destroyed in the fire. At present a new unit has been completely wired except for the connection of the core planes to the control circuitry.

4.12.3.3 Low Speed Terminals

4.12.3.3.1 Monitor Selective Typewriters (5)

The five IBM Selective typewriters were damaged by the fire and returned to the manufacturer for repair. These units are now back in stock but one typewriter is still inoperative. The Selectric typewriters will be wired into the monitors to provide hard copy I/O functions.

4.12.3.3.2 Monitor Magnetic Tape Modules (5)

The five magnetic tape modules were damaged by smoke and the corrosive residue from the fire fighting effects. These units have been thoroughly cleaned but have not been tested due to the elaborate testing apparatus required.

4.12.3.3.3 Mod 33 ASR Teletype Sets

There were seven Mod 33 ASR teletype sets originally assigned to the Illiac III area. One unit was completely destroyed and one unit was partially damaged by the fire. Three units have been temporarily assigned for on-line use with Illiac IV and the remaining two units are operative and will be used for remote I/O with Illiac III.

4.12.3.3.4 Analog Instruments

There is only a token amount of design completed in this area due to prior design commitments.

R. Martin

4.13 Power Distribution

The design of this system is approximately 90% complete, but the fabrication and final assembly is only 30% complete. The status of the various sub-systems is as follows:

4.13.1 Primary D.C. Power Supplies

The DC power supplies (31 total) were mounted in power supply racks, located in Room 284, prior to the fire. Because of extensive heat and smoke damage, exhaustive cleanup and repair efforts were made on these supplies but eight units still remain inoperative. Dynamic testing is now in progress to insure that these supplies will render reliable service.

While it is evident that additional primary supplies are required, initial sections of the machine will be adequately supplied by the units now on hand.

About 60% of the primary distribution cable is laid but is not connected. Routing of the remaining cable will depend on the current requirements in Rooms 280 and 223.

4.13.2 Power Distribution System

4.13.2.1 Primary D.C. Distribution Center (Room 223)

The design of the Distribution Center is about 90% complete and the various sections on modules are now being fabricated. The components used in these modules are in stock and only final assembly is required to complete these units. The modification of the distribution framework is about 10% complete. An additional cable-connector and signal distribution rack has been built and cover panels have been repainted.

4.13.2.2 Primary D.C. Distribution (Room 280)

A tentative design for this Distribution Center has been ordered but no installation has been started. Because of the lack of current-load requirements, the documentation is only about 10% complete.

4.13.2.3 Secondary D.C. Distribution

The wire for secondary distribution has been ordered but no installation has been started. Because of the lack of current-load requirements, the documentation is only about 10% complete.

4.13.2.4 Control of Power Distribution Systems

Power Turnon and Protection - This control system is about 95% designed but no wiring has been done. About 50% of the required printed circuit boards are in stock and the remaining 50% has been ordered. Both the intermediate connector plugs and cables, which connect the mainframe to the protection system, have not been ordered due to the uncertainty of the current-load requirements.

Local Power Regulation Boxes-The design of this system is 100% complete and about 50% of these boxes have been fabricated.

AC Turnon Boxes-The design of this system is 100% complete and only 10% of these boxes have been fabricated.

4.13.3 AC Power Distribution

The primary AC distribution was completed with the new building but the secondary distribution was partially damaged by the fire. This secondary distribution system was rewired and also expanded due to the increased demands of the peripheral equipment. The expanded system includes; a 200 amp secondary panel in Room 280, (2) 200 amp secondary panels in Room 284, (2) 20 amp, 3 phase circuits in Room 217. A tertiary distribution system was installed under the false floors of Rooms 217, 280 and 284 to provide greater distribution flexibility, ease of final installation, and for increased safety to installation and maintenance personnel.

R. G. Martin

4.14 Unassigned Equipment Pool

4.14.1 Printed Circuit Board Inventory

Presently one hundred fifty-one types of printed circuit boards in the Illiac III system have been built. Total quantity of boards on hand at present is 10,500 boards, of which 9,750 are inventoried in numbered boxes within steel storage cabinets, and 750 are checked out to staff members on the project. Another 600 boards are currently fabricated, bringing total on hand and on order to 11,100 cards.

Printed circuit board records have in the past been kept in a series of log-books and card files. A tab-card file for the entire system has been established. The tab-card format permits the recording of basic board identification data, and testing/repair data in great detail. Presently 10,500 cards have been punched with Type Numbers, Serial Numbers, and Locations. The tab-card format further provides for entry of tests performed, test failures (identifying circuit failing, component failing, and type of failure), and repair data as necessary. This system has enabled ready investigation of possible failure trends on a particular board type, and permits any desirable circuit modifications for extreme long-term reliability.

T. E. Kingery

4.14.2 Test Equipment Inventory : Commercial

Extensive modifications in the test equipment inventory of the project were necessitated by the fire -- which largely gutted the fabrication and test area adjoining the computer. Presently available equipment includes the following:

Amount	Type	Mfg.	Model
	DIGITAL VOLTMETERS		
1	dvm	Digitec	201
3	dvm	Hewlett Packard	3440A
5	dvm	Fairchild	7050
	DVM PLUG-INS		
2	dvm plug-in	Hewlett Packard	3441A
2	dvm plug-in	Hewlett Packard	3442A
2	dvm plug-in	Hewlett Packard	3444A
	VOLT-OHM METERS		
10	vom	Triplett	630A (2)
1	vom	Simpson	260
7	vom	Simpson	269
1	vom	Simpson	270
	OSCILLOSCOPES		
1	scope	Hewlett Packard	140A
2	scope	Tektronix	422
3	scope	Tektronix	453
1	scope	Tektronix	545B
2	scope	Tektronix	547
1	scope	Tektronix	567
	OSCILLOSCOPE PLUG-INS		
1	scope plug-in	Hewlett Packard	1415A
1	scope plug-in	Tektronix	1A1
1	scope plug-in	Tektronix	1A2
1	scope plug-in	Tektronix	3T77
1	scope plug-in	Tektronix	3S76
1	scope plug-in	Tektronix	6R1

Amount	Type	Mfg.	Model
2	scope plug-in	Tektronix	M
1	scope plug-in	Tektronix	W
	OSCILLOSCOPE ACCESSORIES		
1	scope camera	Tektronix	C-19
8	scope probes	Tektronix	P6006
4	scope probes	Tektronix	P6008
15	scope probes	Tektronix	P6010
2	scope probes	Tektronix	P6011
6	scope probes	Tektronix	P6012
1	scope probes	Tektronix	P6016
5	scope probes	Tektronix	P6017
1	scope probes	Tektronix	P6019
1	scope probes	Tektronix	P6020
4	scope probes	Tektronix	P6032
1	scope probes	Tektronix	P6034
3	scope probes	Tektronix	P6035
	PULSE GENERATORS		
7	pulse generator	Datapulse	101
1	pulse generator	Datapulse	102
1	pulse generator	Dig. Electronics	521
1	pulse generator	Hewlett Packard	211A
1	pulse generator	Tektronix	114
	POWER SUPPLIES		
2	power supply	DCS	Diode String
1	power supply	Hewlett Packard	721A
3	power supply	Kepco	ABC 7.5-2M
2	power supply	Kepco	ABC 15-1M
1	power supply	Kepco	ABC 30-0.3M
3	power supply	Kepco	ABC 40-0.5M
8	power supply	Lambda	LH 121-FM
1	power supply	Lambda	LH 124-FM
1	power supply	Lambda	LH 125-FM
3	power supply	Lambda	LH 127-FM

Amount	Type	Mfg.	Model
	POWER SUPPLIES (CON'T)		
8	power supply	Lambda	LMC-6
4	power supply	Lambda	LMC-12
5	power supply	Lambda	LMC-18
3	power supply	Lambda	LMC-24
1	power supply	Leichner	C2
1	power supply	Leichner	U2
1	power supply	Mid-East Elect.	
2	power supply	Power Design	2015R
1	power supply	Trygon	RS60-7.5
	CALIBRATION EQUIPMENT		
1	amplitude calibrator	Tektronix	---
1	precision DC divider	Tektronix	---
	SIGNAL GENERATORS		
1	signal generator	E and H Res.	410
1	signal generator	Hewlett Packard	200C
1	signal generator	Hewlett Packard	200CD
1	signal generator	Tektronix	191
	SPECIAL		
1	clamp-on ammeter	Weston	749
1	temp. meter	Simpson	389-3L
1	vtvm		303
4	diode testers	DCS	3
1	recorder	Rustrak	88
1	recorder	Rustrak	111A
1	capacitor decade	C-D	CDC3
1	vtvm	Hewlett Packard	400C
1	gaussmeter	Weston	1890
1	resistance bridge	L-N	5305

4.14.3 Test Equipment Inventory: Custom-Designed

In addition to the commercial test equipment assigned to the Illiac III project, numerous testers have been fabricated to aid speical testing:

1. General card tester
2. Stalactite chip testers
3. Stalactite card tester
4. Over/Under card tester
5. Threshold logic tester
6. Nondestructive diode tester
7. Local power regulation tester
8. General component testers

4.15 Documentation

4.15.1 Engineering Manual

A major portion of the circuit drawings and technical data, pertinent to the engineering aspects of Illiac III, have been compiled together in order to aid the engineering personnel in the design, assembly and maintenance of the various sections of the machine. This manual is continuously updated with the latest revisions of circuitry and new technical information as it becomes available.

R. G. Martin

4.15.2 Circuit Books

Twenty two new circuits have been documented in entirety. Sixty six engineering changes have been processed. Backlog of work on circuit book documentation has been eliminated.

Circuit book manuals have been updated and expanded into two volumes per set.

J. H. Otten

4.15.3 Logic Books

Final logic documentation for the Taxicrinic Processor, Scanner/Monitor, Channel Interface Unit and Exchange Net are in transitional stages of completion.

Logic drafting standards have been established.

J. H. Otten

4.15.4 Wiring Tables

Wiring tables are complete for approximately 50% of the Taxicrinic Processor and Scanner/Monitor. Tables will soon be available for the Exchange Net and Channel Interface Unit.

A programming language (WEB) has been developed for aiding the compilation and use of the wiring lists.

J. H. Otten

4.15.5 Opto/Mechanical Design

Since September 30, 1966, a total of 111 detail drawings and layouts have been made to manufacture opto/mechanical equipment for several Illiac III areas. Modifications and improvements in opto/mechanical design are presently reflected in respective detail and/or assembly drawings. Eighteen engineering change orders have been processed to update respective drawings to reflect modifications in opto/mechanical design.

S. Zundo

4.16 Circuit Research and Development

4.16.1 Card Testing

During the last year the testing procedure for Illiac III Printed Circuit Boards was defined and the construction of the testers begun.

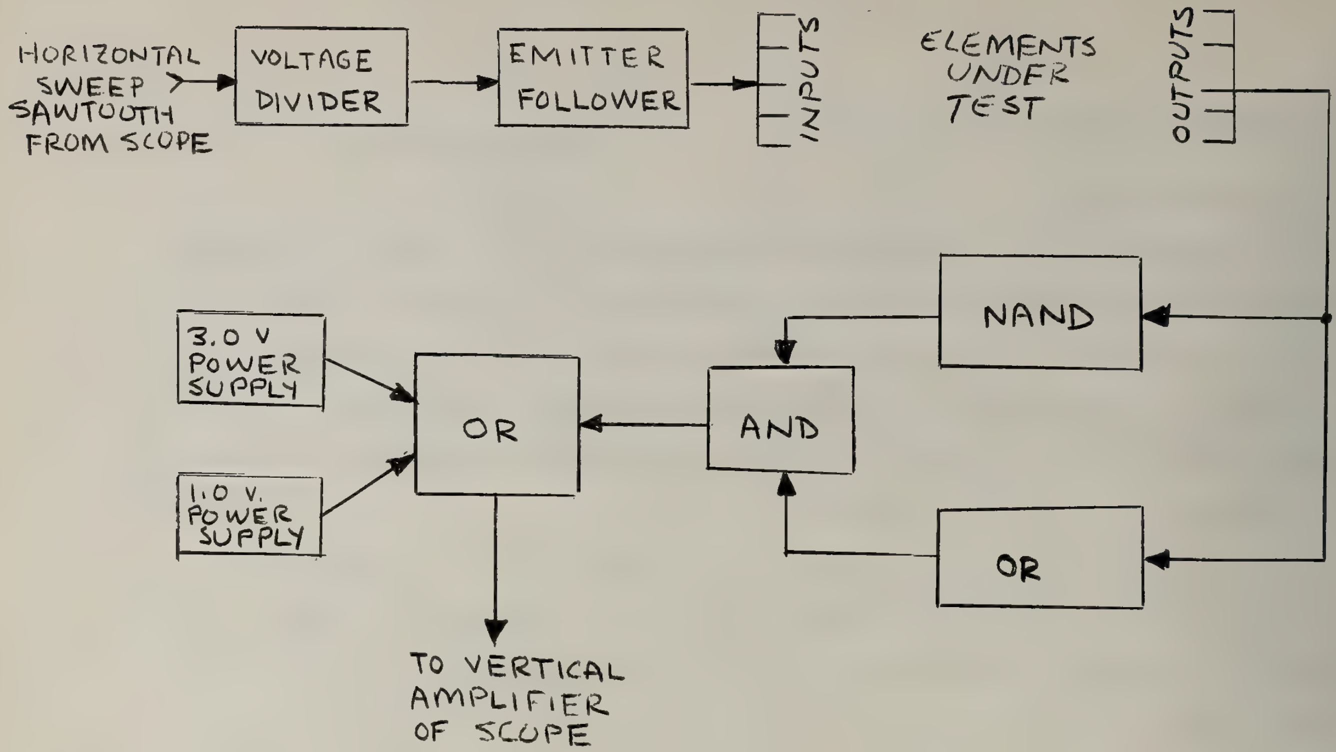
All boards will undergo at least three tests: 1) a dynamic pulse test, 2) a threshold test, and 3) a speed test. In addition special tests will be performed on selected types of board such as two-state stability tests for flip-flops.

Dynamic Tester: The dynamic pulse test is used to check all possible states of the logic element under test. This test indicates whether all components are present, put in correctly, and are of the correct value.

The tester is completely self-contained and consists of an astable multivibrator driving a twelve stage counter. This allows at least 2^{12} possible states with which to test cards. Each board is programmed by means of a wired card connector.

Speed Tester: The speed test is used to measure the average operating times of the transistors in the circuit. The test consists of putting the logic element into a racing configuration and measuring the period of the resulting waveform. Also the outputs of all the elements are connected together with a mixer resistor. This indicates the general condition of the board, i.e. whether diodes are slow, transistors not saturating fully, etc.

Threshold Tester: The threshold tester measures the switching threshold of the logic element. The block diagram of the tester is shown below.



The emitter follower gives power amplification to the ramp whose amplitude varies between 0 and +5 volts. This ramp is applied to the input of the element. The NAND indicates the first element to switch while the OR indicates the last. Thus a pulse is produced whose width is proportional to the range of thresholds on the board. The 1.0 volt and 3.0 volt power supplies are used as references in measuring the width of the pulse.

R. T. Borovec

4.16.2 Hand Wheel Digitizer

The function of the handwheel digitizer is to enable an operator to manually control the position of a reference point on the monitor screen. The position of this point is controlled by its digitized coordinates,which are retained in two external (to the monitor) counters.

Each monitor has two handwheels, one for horizontal control, the other for vertical control, and each handwheel has two output lines which are interpreted by the counters as an increment input and a decrement input. Clockwise rotation of the wheel causes the increment line to be pulsed and corresponds to upward or rightward translation on the screen. Counter-clockwise rotation has the opposite effect.

The digitizer provides one pulse at its appropriate output for every six degree rotation of the handwheel. A pulse represents a positional change of one unit on the monitor, the screen having a 4096 unit (square) dimension. Approximately 68 revolutions are required to transverse the entire screen. An adept operator should accomplish the task in about five seconds with a single vigorous spin of the handwheel.

The handwheel digitizer is essentially an analog-to-digital converter using phototransistors Rotation of the control wheel causes rotation of a plastic disc which has alternate opaque and clear sectors. The disc rotates between a light source and three phototransistors.

Each phototransistor drives a non-inverting Schmidt trigger. The logic of the digitizer is sequential and utilizes three states to decode the outputs of the Schmidt triggers.

The hardware requirements for each monitor are: two mechanical handwheels, one (267-00) Schmidt trigger card, one (228-00) NOR card, and four drivers of a (268-00) cable driver. The system diagram of the system is shown below:

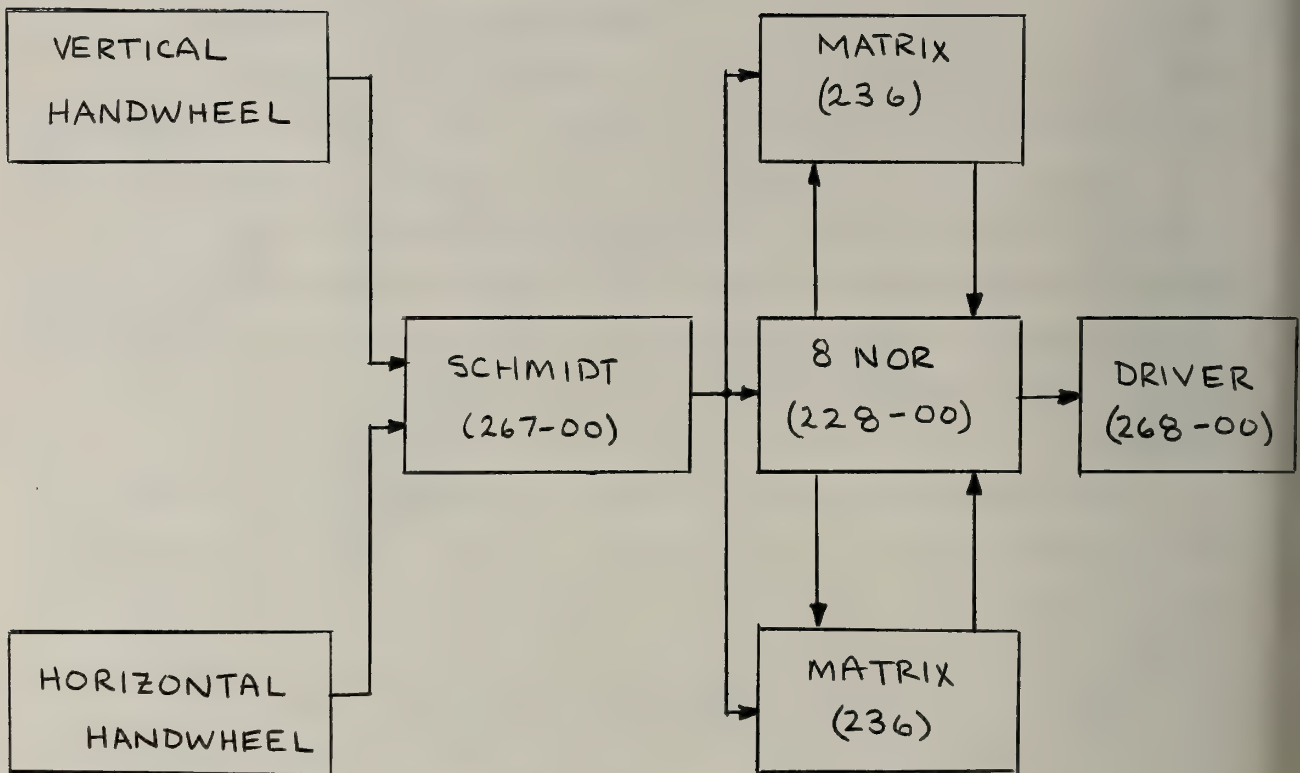


Figure 4.16.2 Logic of Hand Wheel Digitizers

4.17 Bibliography

During the year the following File Numbers, Reports and Specifications have been issued:

File Numbers

File No. 719 "A User's Guide to a Program which Generates Wiring Lists" by William D. Bond, October 31, 1966.

File No. 720 "Ampex Magnetic Tape System for Illiac III" by J. V. Wenta, December 5, 1966.

File No. 721 "Ampex Magnetic Tape System for Illiac III:Tape Stations and Transport Mechanisms" by J. V. Wenta, December 5, 1966.

File No. 723 "A Simple Push Button Pulse Generator" by George Lewis, February 1, 1967.

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4.18 Illiac III Staff[1]

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5. ILLIAC IV

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HARDWARE

5.1 ILLIAC IV Reliability Analysis

The initial study of ILLIAC IV reliability requirements, undertaken last winter, indicated that additional circuit operational data would be helpful. The simplest apparent way to obtain such data was to construct mathematical models of the pertinent logic blocks so that a collection of these models could be assembled to realize various logical configurations. Thus, from the circuit designers viewpoint, their interactive affects might be usefully explored, using conventional analysis techniques combined with Monte Carlo simulations.

5.2 Program Supplementation

A search, made with the cooperation of a number of government agencies and private companies, resulted in the identification of four computer programs, ECAP, PANE, CIRCUS, and SCEPTRE, which after varying degrees of modification, offer potential for DC parameter variation analysis (Schm plots) and transient analysis studies.

ECAP, which has recently been supplied to the University, is scheduled to be implemented shortly on the 360 Model 50. ECAP will be modified so that it will perform non-linear circuit computations and parameter variation analyses.

Concurrently with this program supplementation task, efforts are being made to obtain circuits and circuit elements from Texas Instruments so that measurements of their characteristics may be made for use in constructing an effective circuit model. To date, no components have been received.

5.3 Control Unit and Input/Output System Design

5.3.1 Introduction

Since the PE design was completed in the previous reporting period, the design effort is centered on CU and I/O system design in this period. Logical design of the CU and efforts to identify the necessary control communications between B6500, IOC, and ILLIAC IV are currently under way.

5.3.2 Control Unit

The rate at which instructions can be supplied to the PE's affects the ability to keep the PE's busy all the time. Therefore, it is one of the key factors of the CU design which affects ILLIAC IV throughput. Simulation of various ILLIAC IV programs has been made to optimize the length of the instruction queue (FINQ) in the CU. A maximum queue size of 8 has been determined to keep PE idle time less than 5 percent for the majority of the programs tested.

Overlap is another factor in throughput. Four levels of overlap are now provided; i.e., the CU will be designed to control the following four operations simultaneously for instruction execution:

a. Instruction fetch
b. Central indexing and arithmetic
c. Local indexing and operand fetch
d. Local arithmetic

The multiprocessing capability of ILLIAC IV also received attention this quarter. A set of configuration control registers is provided in each CU to define quadrant concatenation which can be specified by either ILLIAC IV or B6500 program.

5.3.3 Input/Output System

The maximum data rate acceptable for ILLIAC IV is presently 4KMHZ and is expandable to 64KMHZ when desired.

The sources of the data, real time link, and parallel access disk system are possible and are selected at the input-output switch (IOS) where the data bits are aligned appropriately for transfer into the array memories.

The memory disk system currently proposed has 6 disks with a capacity of 500 million bits and a data transfer capability of 500MHZ. Two such systems will be provided to create a 10^9 bit capacity and to allow two simultaneous transfers to take place.

SOFTWARE

5.4 Language Translator Writing System (TWS)

5.4.1 Introduction

The TWS group was established during this quarter under review. Most of the period was spent in surveying the current status of TWS's, generally for which task, the paper by Feldman and Gries[1] gave either direct or indirect access to almost all worthwhile material on the subject. Towards the end of the quarter, definite design objectives began to crystallize, some of which are illustrated below under the appropriate subgroup headings. The next quarter should see the implementation of these design objectives into a working system.

5.4.2 The Symbol Scanner

A scanner for the TWS is being written (in Burroughs ALGOL) which does a fast analysis of basic syntactic elements: identifiers, literals, special words (e.g., _BEGIN_), and strings. The format allowed for these elements is somewhat restricted, e.g., special words must start with (at present) an underscore marker, but since it is being written as a number of fast specialized procedures rather than a few long ones, changes can be implemented easily, either by using the procedures separately from the normal scan mode or by adding other procedures. Also, special purpose procedures will be made available to the user for such functions as a rapid scan to a ";", "end", or "else" in cases of extreme syntactic malformation which are not worth analyzing.

5.4.3 Syntax-Floyd Productions Algorithm

An algorithm is being devised for mechanical conversion of Backus normal form grammar syntax to modified Floyd productions which can be used

as the basis of a fast and efficient parsing algorithm. The algorithm has been written and is now being tested on an unambiguous version of the BNF productions of ALGOL 60.

The basic idea in the algorithm is that the top of the main stack comes from one of three situations. Letting α be any string and X any symbol, the three cases are:

1. $G \rightarrow \alpha X$
2. $G \rightarrow \alpha XH\ldots$

and 3. $G \rightarrow \alpha Xa\ldots$

where G and H are any non-terminals and a is any terminal.

These three are converted to the following Floyd productions:

1. $\ldots\ \alpha X\vert\ \ldots \rightarrow G\vert$	Gt	(reduce to G)
2. $\ldots\ \alpha X\vert\ \ldots \leftarrow \overline{H}\vert$	*Hh	(put $\overline{H}$ on stack and scan)
3. $\ldots\ \alpha X\vert\ \ldots$	*at 3	(scan)

where Gt is the group of all Floyd productions which expect G as the symbol on top of the stack, Hh is the group of all Floyd productions corresponding to all possible single terminal symbol beginnings of H, and at 3 is the single Floyd production with a stack comparison field of αXa as drawn from BNF production number 3.

Identical stack comparison fields within a given group are resolved by a limited contextual analysis (represented by ... in the examples) to see which production applies.

It is felt at this time (pending more thorough testing) that the algorithm will work effectively for most, if not all, "naturally occurring" and unambiguous grammars.

5.4.4 Syntax-Recursive Parsing Algorithm

Several possibilities for a recursive parsing algorithm to back up the Floyd production algorithm for the cases in which it fails have been investigated. A Trout[2] type system--modified to store the tree structure of the given input string before semantic routines are called--has been chosen. The modification of the Trout type system was necessary to make the program completely general.

As syntax of a language is processed, a word is produced for each symbol of the right-hand side of each production. This word contains seven fields: a symbol table number; a pointer to an entry in that table; a flag for recursively defined productions; a flag for the last symbol of the production; a code for the symbol to be pushed into the stack; a flag for the last production with a given left-hand side; and, an entry to the semantic routines table.

In the course of analyzing input strings in the language, the above fields are used to guide the analysis down the syntax until a match with the input string is made. The symbol table number, and, in some cases (the special symbol table and the nonterminal table specifically), the pointer to an entry in that table, are matched with the top of the stack. As long as matches occur, the next symbol of the production is checked until the last symbol in the production is matched; in which case, the semantic routine is called, and the reduction is made.

When a nonterminal is sought, a transfer is made to the part of the syntax where that nonterminal is checked, and a record is kept of the location from which control passed in order to return to it when the terminal is identified. This record is kept in a stack.

When no match is made, control passes to an alternative production having the same left-hand side. When all alternatives have been found false, control returns to the top address in the stack mentioned above with the value false.

5.4.5 Semantics

A review was made of some of the FSL's (Formal Semantics Languages) proposed up to date. With this purpose, references 3-7 have been studied, and the languages that they propose for semantics description were compared. With this background, the following decisions were made.

The semantics language (MFSL: Modified Formal Semantic Language) to be used in the ILLIAC IV TWS will be basically a Burroughs extended ALGOL program. The constructs in the existing FSL's can be roughly classified in three types: 1) ALGOL-like constructs; 2) Features to help compiler description (for example: stack declarations and operations to manipulate them); and,

3) Features to help machine code building. In MFSL, the constructs for type 1 are simply the Burroughs extended ALGOL statements; constructs of type 3 are not needed because of the two pass feature of the TWS for ILLIAC IV, using an Intermediate Language (IL) as the link between pass I and pass II. Constructs of type 3 are going to be provided and implemented in the form of a fixed deck of procedure declarations attached to each MFSL program. The type 2 constructs are now being defined and implemented.

5.4.6 Intermediate Language

In order to avoid limitations and particularizations, there will be no fixed IL with a closed repertoire of instructions. Thus, pass II of the TWS will be implemented in a modular approach; so that, the user can add whatever "instructions" he needs to the IL as soon as he also writes a procedure describing the new instruction. This procedure will then be attached to the pass II translator, and the new instruction becomes available in the IL. After the first few compilers have been written using this system, there will be available a good library of IL instructions along with the procedures defining them. The user will seldom have to define new IL instructions as he will probably be able to describe his semantics using the instructions already present in the library. However, he does have the possibility of adding new instructions when they are needed to allow good efficiency of the generated code.

5.5 Tranquil

The specification for Tranquil[8] was completed, and work on its implementation was done. This involved a final decision on the specification of index sets and the generation of a set of productions.

Investigation is under way on a method of computing in parallel, loop parameters that must be computed at execution time. The determination of which indice should be used for parallel computation (in those assignment statements in which a choice exists) is also being investigated.

Work has started upon deciding and developing routines in accordance with the provisions of the translator group. Pass I involves the generation of an intermediate language. This involves the establishment of tables in

terms of block structures for simple variables, arrays, sets, procedures, labels, user memory specification, and others. These tables are then used to determine what arrays and sets are dynamic in nature. This indication is passed on to Pass II for appropriate action. The intermediate language given on to Pass II, along with the tables previously mentioned, is essentially a reduction in the length of the source language, since pointers to tables are used instead of symbolic names.

5.6 ILLIAC IV Simulator

At the beginning of this quarter, the instruction execution routines for the 7094 MAD version of the ILLIAC IV simulator were written, but the instruction formats and logic were those of the Burroughs Preliminary Report. However, no provision was made for setting interrupt register bits or for doing I/O during execution of a simulated program.

A design for the ILLIAC IV assembly language was proposed in early July and submitted for the general consumption of the applications programmers. An assembly program for this language was coded for the IBM 7094 starting in early August and is currently in the final stages of debugging.

The instruction simulating routines were updated to conform to Revision B of Burroughs Technical Specification, during this quarter. Routines were written to selectively dump the simulated memory and to set and evaluate interrupts. Debugging of the entire simulator was begun, and it was found that the tested instructions worked as expected. The debugging of the simulator, pseudo-monitor was completed.

In late September, debugging of the 7094 simulator system was abandoned due to the arrival of the Burroughs B5500 system. The recoding of the simulator in B5500 ALGOL was begun, and plans are being made to recode the assembler for the Burroughs machine.

5.7 Partial Differential Equations

5.7.1 Introduction

During this quarter, the general direction of applications studies has not changed, although in several areas, coding of problems has been completed. Eulerian hydrodynamics codes have been produced in ILLIAC IV assembly and high level languages. There is no contemplation of further modification of these codes until the full simulator is completed. Also, Hockney's method[9] has been coded in high and low level versions, and modifications of it await the completion of the simulator.

Although codes have been written for two and three dimensional ADI problems,[10] this area continues to be intensively studied. This is due to the importance and wide applicability of these methods, as well as, the existence of several open questions concerning optimum allocation of storage and treatment of irregularly shaped boundaries.

Carlson's S_N method has begun to be programmed, and some of the thorny problems connected with iterating to a solution and mapping the physical grid into the memory have been solved. Plans have been made to consult the nuclear engineering personnel at the University to evaluate the procedure described in paragraph 5.7.3.

5.7.2 Alternating Direction Implicit Method

In solving the heat equation by using ADI, there seems to be a difference of opinion as to the way to store the mesh points. One way is to store the mesh skewed. Another way is to store either columns or rows as vectors in each PE. In RCA's report on ADI of December 15, 1966, the point was made that skewed storage was unnecessary. No matter whose method of ADI is used, a matrix equation is always gotten of the form: (1) $HVX^{(m+1)} = WX^{(m)}$, where H is a horizontal operator, and V is a vertical operator. If X is stored skewed, then both columns and rows can be accessed; hence, both H and V are block diagonal where each block is tridiagonal. By using Gaussian Elimination, both H and V are easily inverted at 100% efficiency on ILLIAC IV. Supposing X is stored in the PE's by columns (i.e., First column in PE 1,

Second column in PE 2, and so on), X can be accessed by columns only. V again is block diagonal where each block is tridiagonal, but H is a block tridiagonal matrix with diagonal blocks. For example:

$$H = \begin{bmatrix} B_1 & C_1 & & \bigcirc \\ A_2 & B_2 & C_2 & \\ & \ddots & \ddots & C_{m-1} \\ \bigcirc & & A_m & B_m \end{bmatrix} \quad \text{AND} \quad B_i = \begin{bmatrix} b_{i,1} & & \bigcirc \\ & b_{i,2} & \\ \bigcirc & & \ddots \\ & & & b_{i,m} \end{bmatrix},$$

$$A_i = \begin{bmatrix} a_{i,1} & & \bigcirc \\ & a_{i,2} & \\ \bigcirc & & \ddots \\ & & & a_{i,m} \end{bmatrix}, \qquad C_i = \begin{bmatrix} c_{i,1} & & \bigcirc \\ & c_{i,2} & \\ \bigcirc & & \ddots \\ & & & c_{i,m} \end{bmatrix}.$$

Let $WX^{(m)} = K$ and $VX^{(m+1)} = Z$ then equation (1) can be written: $HZ = K$. The same storage location can be used for the three matrices X, K, Z and, hence, they will be stored in the same manner. The following notation will be used in the following equations: X_i, K_i, Z_i which are the ith columns in the matrices X, K, Z respectively. We now solve for Z.

$$\text{Let } L_1 = B_1$$
$$U_1 = L_1^{-1} \cdot C_1$$
$$S_1 = L_1^{-1} \cdot K_1$$

Then for i = 2, 3, ... N

You have

$$L_i = B_i - U_{i-1} \cdot A_i$$
$$U_i = L_i^{-1} \cdot C_i$$
$$S_i = L_i^{-1} \cdot (K_i - A_i \cdot S_{i-1})$$

and finally

$$Z_N = S_N$$

For k = 1, 2 ... N-1

$$Z_{N-k} = S_{N-k} - U_{N-k} \cdot Z_{N-k+1} \; .$$

If A_i, B_i, C_i are stored in the ith PE, then only one PE will be on at a time, since L_i, U_i, S_i cannot be calculated until L_{i-1}, U_{i-1}, S_{i-1} are calculated. Suppose m = 256, and that A_i, B_i, C_i are stored across the PE's, i.e., $a_{i,1}$ in PE 1, $a_{i,2}$ in PE 2 ... $a_{i,256}$ in PE 256. So, you have the following situation.

PE 1	PE 2 ...	PEi ...	PE 256
$K_{1,1}$	$K_{2,1}$ ...	$K_{i,1}$ ...	$K_{256,1}$
$K_{1,2}$	$K_{2,2}$ ...	$K_{i,2}$ ...	$K_{256,2}$
$K_{1,3}$	$K_{2,3}$ ...	$K_{i,3}$ ...	$K_{256,3}$
$\vdots$	$\vdots$	$\vdots$	$\vdots$
$a_{i,1}$	$a_{i,2}$ ...	$a_{i,i}$ ...	$a_{i,256}$
$b_{i,1}$	$b_{i,2}$ ...	$b_{i,i}$ ...	$b_{i,256}$
$c_{i,1}$	$c_{i,2}$ ...	$c_{i,i}$ ...	$c_{i,256}$

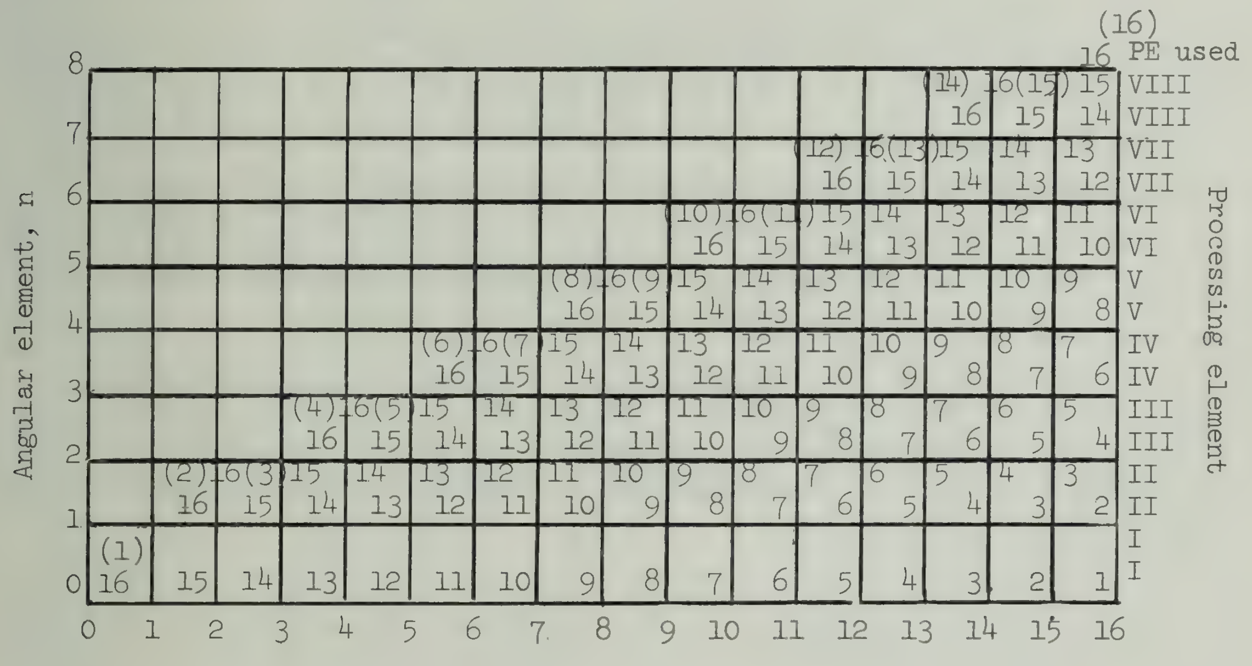
It is clear that L_i, L_i^{-1}, and U_i can be calculated keeping all the PE's busy. It is also obvious that S_i must be stored in the same PE as K_i. However, in attempting to calculate S_i, the product vector $A_i \cdot S_{i-1}$ must be formed, i.e., $(a_{i,1} \cdot S_{i-1,1}, a_{i,2} \cdot S_{i-1,2}, \ldots, a_{i,256} \cdot S_{i-1,256})$. We only have to look at the way the vectors A_i and S_{i-1} are stored in memory to see that a route of every possible length is needed to form the vector $A_i \cdot S_{i-1}$, which is undesirable. So, it appears that skewed storage is the only way to store the mesh points.

In RCA's report on ADI, they proposed the following technique to avoid skewed storage. First the mesh points are stored by rows in the PE's, i.e., 1st row in PE 1, 2nd row in PE 2 ... 256th row in PE 256, then the horizontal operator H is block diagonal with tridiagonal blocks. Gaussian

Elimination can be used as suggested before. After the horizontal operator has been inverted, the X matrix is transposed in memory. Therefore, X is now stored by columns in the PE's, and the vertical operator V can be inverted the same way as the horizontal operator was by Gaussian Elimination. Following the invertion of V, the X matrix is again transposed. So, after every operator is inverted, the X matrix must be transposed--this is clearly not the case when the mesh is stored skewed.

5.7.3 Carlson's Method

In the numerical solution of the steady-state neutron transport equation by Carlson's discrete S_N method in isotropic media and spherical geometry, the following mesh scheme results for an S_{16} calculation when the angular segments are negative:



Radial element, j.

The numbers indicate the order in which the points may be calculated using the S_N difference scheme. Disregarding the special calculation for line n=0, it is proposed to use 8 processing elements for each group. Each processing element would compute two horizontal lines, as shown in the figure. For example, processing element I would compute print $16^{(1)}$, processing element II

would compute $16^{(3)}$, ..., processing element VIII would compute $16^{(15)}$. Since the calculation of these points are similar, all $16^{(i)}$, where i=1, 3, ..., 15, would be computed simultaneously. At the next step, PE I would compute $16^{(2)}$, PE II would compute $16^{(4)}$, ..., PE VIII would compute $16^{(16)}$ simultaneously, since again the calculation is similar for all $16^{(j)}$, where j=2, 4, ..., 16. When the angular segments are positive, the calculation is performed in the opposite direction, but there is a similar ordering of points.

5.7.4 Slip Flow Problem

The slip flow problem is, generally speaking, a hydrodynamic problem with the so-called slip boundary condition at the surface of a body in motion, in a fluid. It is well established that the classical boundary condition of zero fluid velocity at the surface is not appropriate when the Knudsen number K_n is in the neighborhood of some known value. Such a situation occurs when the Reynolds number R_e is very small (slow speed flows) or the Mach number M is large (hypersonic flows). It can occur in flows of any speed so long as M and R_e have relative values that yield values for K_n in the neighborhood of the above mentioned value ($K_n = f\ (M, R_e)$). (The slip flow problem is often encountered by aerodynamicists in the study of the aerodynamic characteristics of sharp edged bodies in flight.)

The present study of the slip flow problem is being limited, at the present, to that arising in slow speed flows past a flat plate. Later, the analysis is expected to be extended to high speed flows and other sharp leading edged bodies.

The governing equations are, usually, a system of nonlinear first order, partial differential equations, representing the conservation of mass, momentum, and energy in a viscous fluid flow. These equations are often called the Navier-Stokes equations.

Our task is to solve the equations,

$$U \frac{\partial U}{\partial x} + \nu \frac{\partial U}{\partial y} = \nu \frac{\partial^2 U}{\partial y^2},$$

$$\frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} = 0$$

This system has been reduced through the introduction of the stream function Ψ and the use of a coordinate transformation to

$$\frac{\partial U}{\partial x} = \frac{1}{R_{e_{\lambda\infty}}} \frac{\partial}{\partial \Psi} \left[U \frac{\partial U}{\partial \Psi} \right] .$$

A differencing scheme is being employed to solve this last equation in the $x - \Psi$ space. The results would then be transformed back to the $x - y$ space.

The boundary conditions used (after the transformation) are:

$$U \ (\Psi, 0) = 1$$

$$\left. \frac{\partial U}{\partial \Psi} \right|_{(0, x)} = 1$$

$$U \ (\infty, x) = 1$$

5.8 Signal Processing

5.8.1 Phased Array Radar Data

The application of ILLIAC IV to phased array radar data processing was started during this quarter. A particular model of a radar was obtained from RCA as part of a study that they are performing under Rome Air Development Center sponsorship. This radar is a system designed for Urban Defense against enemy missile attacks. The problem has been subdivided into the following subtasks in which the Computer must play an important role: 1) Beam forming, control, and scheduling, 2) Scan control, 3) Designation (search cloud for persisting items), 4) Tracking, and, 5) Discrimination and interception. Each subtask is being investigated in detail for methods of solution and is then being programmed for the ILLIAC IV.

5.8.2 Cooley-Tukey

A typical array processing problem was coded in the ILLIAC IV high-level language (Tranquil). The problem included convolution and Cooley-Tukey codes, which were found to be pleasantly succinct when transcribed into Tranquil.

Other work done on Cooley-Tukey found a more convenient way to do Cooley-Tukey unscrambling. The new unscrambling algorithm is rather general and is easily Tranquilized. (It is similar to the program used to execute the Cooley-Tukey iterations.) It was also found that the Cooley-Tukey "kernel" was useful in performing real-time beam forming.

5.9 Matrices

5.9.1 Gauss-Seidel Iteration

A program in high level language was written to solve the problem of n simultaneous linear equations in m unknowns using the Gauss-Seidel iteration method. Also, the best technique for multiplying sparse and dense matrices in ILLIAC IV's high level language was investigated; taking into account the parallel aspect of the machine. Programs for Sparse Vector x Dense Matrix, Sparse Matrix x Dense Matrix, and Sparse Matrix x Sparse Matrix were written in ILLIAC IV high level language during this quarter.

5.9.2 Eigenvalue Problems

Eigenvalue problems can be divided into two categories--one for symmetrical matrices, and the other for non-symmetrical matrices. In this quarter, the concentration has been on symmetrical matrices and on how they can be utilized by ILLIAC IV.

There are many methods for finding the eigenvalues and eigenvectors of a symmetrical matrix. Two of the most popular ones are Jacobi's method and Householder-Given's method. In order to apply these methods effectively on a parallel computer, several modifications were made to both of the methods. Since the matrices which were dealt with are symmetrical, there is a possibility of using a special storage scheme on ILLIAC IV.[11]

Several experiments have been made on the IBM 7094; the results show that the Jacobi's method will converge very fast if the diagonal elements of the matrix are dominant. Although Householder's method also works for non-diagonal dominant symmetrical matrix; yet, due to the simplicity of the algorithm and the more effective use of the parallelism of Jacobi's method, it was decided to use Jacobi's method as long as the matrix is diagonal-dominant. A Tranquil language code has been completed for the Jacobi's method and is near completion for Householder's method.

For non-symmetrical matrices, the LR and QR algorithms are the two basic methods used presently. Because there are many restrictions with the convergence of the LR algorithm (i.e. eigenvalues have to be distinct, the matrix cannot be singular, LR decomposition has to exist, etc.), it was decided to concentrate on QR algorithm, since it converges for any matrix. The QR algorithm, including an origin shift scheme, will work for any matrix--even for the ones with complex-pair eigenvalues.

5.10 Linear Programming

5.10.1 Introduction

The ILLIAC IV linear programming effort is directed toward coding algorithms in ILLIAC IV assembly language. Achievement in three areas during the past quarter is outlined below.

5.10.2 Integer Linear Programming

This effort has two objectives that are trying to be attained. The first objective is to gain some practical programming experience in data packing schemes for large size integer linear programming problems. A code Scatre was written for this purpose using Gomory's algorithm II. The other objective is to gain knowledge in estimating ILP running time per iteration and convergence and to learn the working procedures of this ILP algorithm. It is the belief that these two objectives will be useful for future ILLIAC IV integer linear programming implementation and general large scale linear programming implementation as well.

5.10.3 Linear Programming Algorithm

A brief survey on linear programming algorithms was made. Comparisons of different algorithms with respect to their rate of convergence and number of iterations required were made so that the selection of a favorite algorithm for implementation could be made. A strong recommendation for the gradient projection method was found in this study since it may be apt for future ILLIAC IV linear programming implementation. The advantage of this method over other conventional algorithms was mentioned in this study which appeared in ILLIAC IV Document No. 163. Also, investigation on product form

revised simplex method was done, and detail mathematical operation procedures for ILLIAC IV implementation were written along with mathematical descriptions. The product form revised simplex method appears to be very promising for large scale linear programming implementation in ILLIAC IV.

5.10.4 Linear Programming Coding

A totally contained linear programming code was written in ILLIAC IV assembly language employing the general form revised simplex method. Schemes for packing and referencing sparse vectors were examined extensively, and special provision was provided for an unusually long vector. Storage schemes for activity matrix and inverse of basis were defined in association with control scheme for data indexing and manipulation techniques. A method of optimizing the number of arithmetic operations, i.e., to minimize the zero arithmetic operations, was provided so that the least amount of time will be wasted in arithmetic operations. Finally, an estimation of the maximum size of a linear programming problem which could be totally contained was made, and time per iteration was estimated. A rough estimation of this totally contained code indicated improvement of 6,000 times in speed if implemented in ILLIAC IV than that of a comparable code implemented in IBM 7094.

The work of the immediate future will be to evaluate this totally contained LP code and check for proper arithmetic precision and error analysis and estimate the exact time required. A larger scale system will also be implemented by using product form revised simplex method, and the same analysis will be made as for the totally contained code. Other algorithms will also be investigated in order to explore the possibilities of their feasible implementation and improvement.

5.11 Computer Graphics

5.11.1 Introduction

In a sense, this quarter marks the end of the first stage of the ILLIAC IV weather effort. After study and work on the general circulation material provided by John Gary of the National Center for Atmospheric Research, it is evident not only that parallel processing could be a highly useful tool in weather computation, but also that ILLIAC IV will be a significant improvement over any computer now in use in that field.

In the next months, the focus will shift from specific coding problems to the generation of general programming aids to help meteorologists interested in using the ILLIAC IV system.

5.11.2 Timing Study

The NCAR general circulation model was timed on the timing simulator developed by Burroughs Corporation, with the result that the code was found to be efficient and required 32 milliseconds to advance an eight-variable-55,000-mesh-point-model one ten-minute time step ($\cong$ 20,000:1 real time to computing time ratio). The completion of a Tranquil version of this same model was accomplished in this quarter.

5.11.3 Contour Mapping Algorithm

The general contour mapping algorithm was altered to fit the weather problem. Previously, the vectors were to be projected onto an orthogonal grid which only required scaling. Since the accuracy of the weather maps would not be noticeably affected by deletion, it was decided that half of the weather data would not be used because it made the technique much more cumbersome. However, data was added in the region around the North Pole in order to make its data fit a rectangular grid. This added data was obtained by interpolating the existing data. Therefore, the vectors were transformed to be viewed on a polar projection of the world. An ALGOL program was written for the B5500 to order the vectors. The documentation for this work, which will include timing estimates, awaits new ILLIAC IV assembly code description.

5.11.4 Graphical Display Programming System

A simple graphical display programming system is being developed. The system allows the user to define a set of subfigures, each of which contains points and lines. The user may then merge, move, or perform other manipulations on individual subfigures or on groups of subfigures. Subfigure movements are described by 4 x 4 homogeneous coordinate transformation matrices; however, the scaling parameter for the coordinates of a point is always set to unity and thus is not stored. The entire system is written in FORTRAN. Also, the entire system is designed about a matrix (rather than a linked list) data structure; so that consideration may be given to the use of ILLIAC IV for solution of complex structures.

Future plans include a specification of planes and surfaces, so work with hidden lines may be done, and an analysis of line movements given a specification of the joint between two lines.

5.12 Codes for Tranquil

Two codes for the Tranquil language were written--a sorting algorithm and an interpolation procedure. The sorting algorithm involves sorting 512 numbers in 256 PE's by comparison in each PE and in left, right routing. The result is a n-square (512^2) sort in approximately 256 comparisons and 512 left and right routes. Odd and even numbered PE's must be turned off and on after each comparison and route. Combining sets of 512 sorted numbers with other sorted sets is simple enough by calls on the sort procedure, but organization is complex. Some formulas for number of sorts were derived for sorts of 2^k numbers.

The interpolation procedure derives values for R pairs of coordinates (X_r, Y_r) from a rectangular space defined by lattice points with values attached. The interpolation is linear on the smallest enclosing triangle formed by a side of a rectangular area and the two diagonals.

5.13 Non-Numerical Applications

A brief study of techniques for doing information retrieved on ILLIAC IV was begun and completed. Specifically, sequential, binary, and hash addressing schemes were investigated, and the results indicate that sequential and hash addressing schemes are most applicable on ILLIAC IV. Several techniques were developed for doing binary searches, and it was shown that the average search time is proportional to log (n/256) as opposed to an average search time proportional to log (n) for a nonparallel machine.

Work was begun on the design of a list processing language which is intended to serve as a base language for display, list processing, and other applications. This language will be similar to Bell Telephone Laboratories' Low-Level Linked List Language (L^6).

5.14 Population Genetic Program

In this quarter, work was centered on the populational genetic program. Several sections, namely "Generation", "Mutation", and "Conversion", were reduced to a trial form of machine code and were sent off for simulated running. These stages create a stored set of random numbers in the population cells, perform the requisite cyclic mutations on the population, and convert the DNA base representations to amino acid representations for use in the Selection stage.

Other stages of the program have not yet become so clearly defined. The "Mating" stage, responsible for simulating the reproductive part of the genetic cycle, is well defined in principle, but its exact format depends heavily on the mechanics and structure of the input-output routines and thus, cannot yet be well-defined in code form. The "Selection" stage is ill-defined in theory. The more simplistic approach used on the 7094 program seems inappropriate for the more sophisticated capabilities of the ILLIAC IV. Therefore, a further examination of the natural processes as contrasted with the potentials of simulation on this computer will be necessary before an exact coding is possible.

In addition to the population genetic program several other problems have been speculatively considered. These include among others: constellation of points representation of human skulls with the aim of comparison and transformation in answer or clarification of certain questions of taxonomy and evolutionary change; the analysis of archeological data, especially by four-dimensional Rowean seriation; and, network analysis of social anthropological data. Reports, both of the nature on the populational genetic program and on speculations concerning the applications of ILLIAC IV to various anthropological problems, are in preparation.

REPORT SUMMARY

The subcontract with Burrough's was executed during this quarter. The major feature of this contract is cost-reimbursability up to the point of 16 PE checkout. At this point, an option exists to convert the contract to a fixed price basis for the remainder of the program. The incentives during the cost-reimbursable phase are approximately divided equally between schedule cost and performance.

It is expected that during the forthcoming quarter, Burrough's will implement a similar sub-subcontract with Texas Intruments. The progress of the work is, in the interim, continuing and will in no way be affected by delays in implementation of formal paper.

Finalization of the PE design is being completed. This finalization, together with the subsequent release to Burrough's of detailed design and the release by Burrough's to Texas Instruments of package and board specifications, is currently at least two months behind schedule. This and comparable details in CU specifications will result in overall program slippage of several months. Rescheduling will be carried on in detail during the forthcoming calendar quarter, and a detailed schedule will be submitted with the next Quarterly Progress Report. In the PE memory area, there are small slippages which it appears can be made up without affecting the overall program schedule. The PE memory performance on the other hand looks very good, and there is a reasonable expectation that it will exceed the contractually required 250 nanoseconds.

The 6500 and ILLIAC IV disk definitions are finalized with no changes to report in previously submitted costs, performance, or schedules.

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6. NUMERICAL METHODS, COMPUTER ARITHMETIC AND ARTIFICIAL LANGUAGES

(Supported in part by the National Science Foundation under Grant No. NSF-GP-4636.)

6.1 Numerical Analysis

The following Ph.D. thesis was completed during the quarter:

Variable Successive Over-Relaxation
by Leland K. McDowell

The abstract of this thesis follows:

This thesis investigates the solution of linear systems by extrapolated Gauss-Seidel iteration using a multiplicity of extrapolation parameters. This is a generalization of the method of successive over-relaxation, which uses a single scalar extrapolation parameter. The linear systems considered are those which arise in the numerical solution of boundary value problems for self-adjoint, elliptic partial differential equations.

In Chapter 2 it is shown that the use of two appropriately chosen scalar extrapolation factors yields an iteration having a higher rate of convergence than SOR, and formulas are derived for choosing the factors optimally. Also, it is shown that by the use of extrapolation matrices, an iteration can be constructed whose matrix is nilpotent, i.e., whose rate of convergence is infinite.

Chapter 3 considers a more limited class of linear systems for which a certain sort of spectral decomposition is possible. For the solution of such systems the SEI and VSEI methods are introduced and shown to be equivalent to several simultaneous extrapolated Gauss-Seidel iterations on certain subspaces, each with a different extrapolation factor or set of factors. Theoretical and experimental results are presented which show that SEI, which requires less work per iteration than SOR, has the same asymptotic rate of convergence and, for most starting vectors, an improved actual rate of convergence. Experimental evidence is presented showing that certain versions of VSEI have a higher asymptotic rate of convergence for the problems considered than SOR.

(L. K. McDowell)

6.2 Computerized Mathematics

We have been considering polynomial remainder sequences (PRSs) as a possible method for answering the question: Given a set $S(A_1, \ldots A_m)$ of polynomials in several variables and a polynomial B, does the set S imply B. The PRS of two polynomials A and B is the sequence of polynomials $R_1, R_2, \ldots$ where $R_1 = A$, $R_2 = B$, $R_{L+2} = L(R_L)^{\delta_{L-1}} R_{L-2} - H_{L-1} R_{L-1}$ $L = 1, 2, \ldots$ where R_{L+2} is the (unique) such polynomial, H_{L-1} the corresponding "quotient" and $L(R_i)$ denotes the leading coefficient of R_i.

The major problem in calculating a PRS is the explosive growth of the coefficients. It is therefore important to remove common factors of the coefficients whenever possible. We have proven a lemma demonstrating the exponential growth of common factors in the coefficients.

<u>Lemma</u>: If $R_L = \bar{R}_L K_L$, $L = 1, 2, \ldots$ where K_i is in the integral domain containing the coefficients of the R_i, and if $\delta_L = \deg(R_L) - \deg(R_{L+1})$, then $K_{L+2} = K_L(K_{L+1})^{\delta_L}$.

Collins ("Subresultants and Reduced Polynomial Remainder Sequences," JACM, Vol. 14, No. 1) has shown how to form a reduced PRS (RPRS) by dividing each R_i, $L = 4, 5, \ldots$ by $L(R_{L-2})^{\delta_{L-3}}$ before going to the next step. Collins shows this is always possible and our lemma shows how important it is to do so.

An alternate method of division is to form $\bar{R}_{L+2} = L(\bar{R}_{L+1})^{r_L} \bar{R}_L - \bar{H}_{L+1} \bar{R}_{L+1}$ where r_L is the smallest integer that will work. Note that $r_L \leq \delta_L$. We have proven a lemma comparing the RPRS with the PRS formed by the alternate division method.

Lemma: Let P_1, P_2 ... be a RPRS and $\bar{P}_1$, $\bar{P}_2$, ... a PRS formed by the alternate division method. Then $P_L = \bar{P}_L K_L$ where $K_1 = K_2 = 1$, $K_3 = L(\bar{P}_2)^{\delta_1 - r_1}$ and $K_{L+1} = L(\bar{P}_{L+1})^{\delta_L - r_L} L(\bar{P}_{L-1})^{-\delta_{L-2}} K_L^{1-\delta_{L-1}} K_{L-1}^{\delta_L}$ for $L \geq 3$, or alternatively, $K_1 = K_2 = 1$, $K_3 = L(P_2)^{\delta_1 - r_1}$ and $K_{L+1} = L(P_{L+1})^{\delta_L - r_L} L(P_{L-1})^{-\delta_{L-2}} K_L K_{L+1}^{\delta_L}$.

From this we can show, for example, that if $\frac{\delta_{L+1} - 1}{\delta_L} > \frac{r_L}{\delta_L}$, then the (L+3)th reduced remainder is divisible by an additional $\delta_L(\delta_{L+1} - 1) - \delta_{L+1} r_i > 0$ factors of $L(P_{L+1})$. This can be used to decide which method of division will give the simplest result at the next step <u>before the division is carried out</u>.

We also showed there does not exist a single algebraic formula for calculating the coefficients of the remainder of A by B directly from the coefficients of A and B unless deg(A) = deg(B).

(L. J. Henschen)

6.3 Autonomous Arithmetic Unit Structures

Work is continuing on the analysis of possible micro-instruction sets and the preparation of detailed flow charts for the arithmetic operations.

The necessity of normalized double length operands (dividends and products) required the inclusion of a micro-instruction to exchange adjacent digits of the accumulator. This micro-instruction effects a left shift of the accumulator and the insertion of a digit determined by the primitive control unit into the least significant position of the accumulator.

The preparation of a report of this investigation continues.

(M. J. Pisterzi)

6.4 Algebraic Manipulation

Most of the work done during July and August involved further debugging of the IL5 list processor and the syntactic analyzer described in the last progress report. Also, attempts to put IL5 on the ILLIAC II time sharing system were continued but unsuccessful mainly due to the size of the programs and to problems encountered when trying to perform disk swaps and core overlay manipulations on the BOOTS time sharing system. In September it was decided to postpone work on the implementation and rather put efforts only on the theory involved in polynomial manipulation.

The study of redundancy in polynomial manipulation by the use of finite field models of the polynomials in n variables with integer coefficients was started. Theorems required for the consistent definition of the models have been derived and a set of theorems specifying relations between the polynomial in n variables and its model are being developed. The object of the study is to show that the models can be used for error checking and for probabilistic prediction of properties of the polynomial resulting from an operation on polynomials in n variables when corresponding operations on the finite field models are performed.

(S. J. Nuspl)

6.5 Artificial Languages

6.5.1 Symbol Manipulation Languages EOL

A preliminary study was made by L. Lukaszewicz aiming at the inclusion of direct-access mass storage into the EOL system. Professor L. Lukaszewicz left at the end of July and the EOL project was continued at the Department under the direction of Professor Jurg Nievergelt.

Reports No. 241, "EOL Report" and No. 242, "EOL Programming Examples: A Primer," by Leon Lukaszewicz and Jurg Nievergelt were completed.

The implementation of the EOL language on the IBM 7094 by Freda Fisher, Marek Irwin and John Sidlo continues and is now in the debugging stage. EOL will be used in two computer science courses during the Fall Semester, 1967.

(L. Lukaszewicz, J. Nievergelt)

6.6 A Translator Writing System

A structure for a translator writing system (TWS) which yields a n-pass ($n \geq 2$) compiler has been devised. The two most important features of the system are the high degree of modularity, and the ease with which extra passes can be incorporated. It is anticipated that most of the system, if not all of it, will be written as a single program in a high level language, such as Extended ALGOL or PL1, which has string and character manipulation facilities and block structure. The total system is partitioned into n+2 sections as described below.

The first section is a syntax preprocessor, the input to which is a BNF syntax specification of the given source language L. These BNF productions contain pointers (statement numbers) which reference appropriate semantic action routines to be executed during pass 1. The preprocessor checks the syntax of the language for ambiguity, builds syntax tables to be used during the analysis in pass 1, and makes entries in the symbol tables used during the symbol scanning phase. To make the system more general it should contain several different parsing algorithms in which case the preprocessor would, after inspecting the syntax of L, decide which algorithm to use and build the tables in a form appropriate to that algorithm. Much experimentation could, and should, be done in comparing the relative efficiencies of different parsing algorithms. At this stage two different algorithms are being considered: the recursive descent method and a modification of Floyd-Evans productions.

The symbol scanner, to be invoked as each new terminal symbol is required by the parsing algorithm in pass 1, will concatenate source language characters into one of the five symbol categories: special word, special symbol, identifier, numeric literal or string literal. Fixed procedures will be used to handle each of these terminal symbol types but there will also be a capability to bypass these procedures if the specifications of L warrant such action, or any of them may be replaced by an alternative one.

The parsing algorithm will request symbols from the scanner, analyze the syntax of the source program and make calls on the appropriate semantic routines when a syntactic construct is recognized. These semantic routines, called Semantics 1, also will be written in Extended ALGOL or PL1 but will make extensive use of specially made procedures which will facilitate the construction and use of compile time tables and stacks and other activities appropriate to compiler writing. The function of Semantics 1 will be to transform a source string in L into an intermediate language (IL) string which is both source language and object machine independent to the greatest possible extent and to construct descriptor tables to be associated with that IL string.

Passes 2 through n will make further transformations on the IL string using the information in the descriptor tables and Semantics 2 through n before finally producing the required object machine code at the end of pass n. Normally n will be 2 and Semantics 2 will include a set of routines which will convert the IL operators and operands into object code, where the operators will specify which semantic routine is to be used and the operands will be, effectively, parameters to those routines. When it is desired to optimize the final object code by manipulating the order of the IL code, or locating common subexpressions, n will be greater than 2.

The designer of the language L will have to specify the syntax of L in BNF and include therein links to the appropriate routines of Semantics 1 which he will also have to write, along with Semantics 2 through n. The data transmitted from pass i to pass i+1 is the string output together with the tables generated during pass i. Both of these are functions of Semantics i alone, and are therefore known to the language designer before he writes Semantics i+1.

(R. S. Northcote)

7. COMPUTATIONAL PHYSICS

7.1 Approximation of Wiener Integrals

The following is the introduction to a paper titled, Approximation of a Conditional Wiener Integral, prepared during this quarter.

With the growing power of computing machinery, the connection between the diffusion equation and the Schrödinger equation is being exploited for numerical computations. Our particular interest has been in quantum statistical mechanical computations which use this connection, others have used it for the computation of atomic wave functions. In one instance this is the only method which has provided useful numerical solutions; namely, the three-particle computations on helium. In the case of the quantum statistical mechanical computations the Wiener integral is the mathematical foundation supporting the numerical work which is, primarily, an evaluation of a certain Wiener integral. Thus an interest has developed in techniques for making this evaluation and here certain of these techniques are discussed.

There are two rather distinct aspects to these computations: one involves a direct approximation of a Wiener integral; the other involves a Monte Carlo sampling procedure. Here attention is directed at the first of these. One method for direct approximation of a Wiener integral is based on a functional Taylor series expansion, a form of which is known as the Wigner-Kirkwood expansion. This is the method which has been used in the three-particle computations. Another method is a "Simpson rule" for Wiener integrals developed by Cameron and a generalization of this developed by Konheim and Miranker. The Simpson rule approach does not seem to have been employed in any interesting physics computations.

Cameron's Simpson rule cannot be used directly for the type of Wiener integral which arises in the quantum statistical mechanical computations. Here a simple extension of Cameron's idea is used to obtain a corresponding rule for these computations. The application of the Konheim, Miranker generalization is also described here along with an alternate derivation of their result.

L. D. Fosdick

7.2 Path integral programs

During this period, a number of subroutines for the numerical evaluation of path integrals, which had been written in machine language for ILLIAC II, were converted to FORTRAN for execution on the 7094 and 360 system.

L. D. Fosdick and R. C. Jacobson

8. SWITCHING THEORY AND LOGICAL DESIGN

Since Gomory's algorithm was found inefficient for our logical design problem by integer linear programming, we started to look for better algorithms through literature.

The synthesis procedure of adaptive network by linear programming was formulated by T. Ibaraki and S. Muroga. The dual simplex method is modified. The maximum input tolerance, i.e. the maximum reliability of the network is guaranteed by linear programming.

The logical design problem that an optimum network is synthesized, using a given set of basic switching gates, is formulated by S. Muroga and T. Ibaraki, using integer linear programming and a mathematical technique of threshold logic. The basic switching gates to be used in the network are not necessarily threshold elements but could be NOR and NAND, or any other arbitrary ones.

S. Muroga

9. ILLIAC II SERVICE, USE, AND PROGRAM DEVELOPMENT

(This work is supported in part by Contract No. AT(11-1)-1469 of the Atomic Energy Commission and in part by the University of Illinois.)

9.1 Library Programming

9.1.1 Mathematical Subroutine Library

During this period our activity was considerably below normal because of summer vacations. Most of the time was spent in becoming acquainted with the new 360 system. Some subroutines written in the previous quarter were tested on the new 360 system during this quarter. Mr. Jerry Beck of the consulting group prepared for us a program allowing storage, up-date, and retrieval of library subroutines through the IBM 360 operating system. Preparation of library subroutine write ups in this format was begun.

L. D. Fosdick, Project Director
S. Chase
R. Fleck

9.2 CalComp Digital Incremental Plotter

The CalComp Plotter ran for 340 hours in July, 495 hours in August, and 353 hours in September. This over ran the two shift, five-day week operation by 20 hours in July, 127 hours in August, and 33 hours in September.

To help give faster turn around for short jobs a new category called "Express" was started in the month of August. In this category users are allowed only 15 minutes of plotter run time. The regular category is allowed 90 minutes of plotter run time, and specials can have any amount of time needed, with the stipulation that specials will not be run but once a week, or whenever back log permits.

The number of jobs run on the plotter was around 2000 for each month this last quarter.

Minor repairs were made to the plotter on the average of one time every two days.

The Model 763 Zipmode Plotter with a Model 110 controller for on-line operation with the 360 is now on order. It was decided to use in-house maintenance on this system as well as the off-line system. It was also decided that since on-line operation will involve 360 operations, the plotter operators will be integrated with the computer operators. The operator on the plotter will only operate the plotters for that shift, and not have other equipment to operate as well.

T. E. Kerkering

9.3 338 Machine Modifications

A modification was put in the PDP-8 interface to the 630 which inhibits the "SKIP BUS".

Six cables were made up which completed the cables necessary to check out the PDP-7 interface to the 2701 simulator. Three additional cables were made up to go to the PDP-7 interface indicator panel. A static check of the PDP-7 interface to the 2701 simulator was begun on July 3, 1967.

Mr. Gil Slaw from DEC was here on July 24 and 25 to put in the 60 cycle sync. mod. which now works. Another mod. was attempted on the 338 but had to be removed as the mod. would not work. The DnØ1 (data multiplexer) in the PDP-8 system is still inoperable.

Mr. Gil Slaw from DEC arrived on August 29, 1967, to repair the 338; memory bank 3 was failing due to an improper termination; replaced the address switch; installed ECO's 156 and 171 in the 338; DMØ1 (data multiplex) changed terminators on BT2 and address ACC from 47Ω to 100Ω and now the 338 multiplexes.

Mr. Gil Slaw installed an ECO #103 in the PDP-7 on August 30, 1967. This change only involved the reader section.

9.4 1469-2701 Simulator

The 1469-2701 simulator was designed and wired. The simulator uses all Motorola 700 series integrated circuits. The board used for the wire wrapped connections was an Augat Incorporated 8136 series with plug in capability for 60 IC's. We wired 43 IC positions using #30 insulated wire.

The simulator and PDP-7 interface has been checked out for most of the control logic and transfer data correctly both in the read and write mode. The simulator's data comparator is not functioning due to a misinterpretation of Motorola literature on their 700 IC series. This will be corrected as soon as additional IC's that are on order arrive.

Final testing on the 2701 simulator has been completed. The 2701 simulator is operational and performing error checks.

9.5 Other Equipment

A partial interface for the Ampex RF1 memory, for the Terminal Display Project, has been designed and preliminary drawings prepared. Hardware for this part of the interface has been ordered. An integrated circuit mounting system has been devised utilizing Elco wire-wrap IC sockets and a panel designed in hours.

An inventory of all DEC (Digital Equipment Corporation) cards used in DEC equipment and the number of spare cards on hand has been completed.

One 4708 DEC receiver card has been modified to a 4706 receiver card and checked out as being operational. One 4709 DEC receiver card has been modified to a 4707 transmitter card and checked out as being operational.

The dataset group 5 (eight ports) were checked out at the end of the month as being operational.

H. E. Lopeman, R. L. Miller

9.6 Engineering Maintenance

9.6.1 ILLIAC II Engineering Log Summary

9.6.1.1 July

Unit	Errors	Comments
A.C. Power	1	300 Amp. Ckt. Breaker Marginally Loaded
Core 0	1	
Core 1	0	
A.C.	0	
Console	1	
Drum	0	
SPU Channel	0	
Tape Channel 4	0	
Tape Channel 5	0	
D.C.	0	
MAU	1	
Flow Gating	0	
MSRDP	0	
Tape Drives	7	Unit A = 1, Unit B = 1 Unit C = 2, Unit H = 2, Unit G = 1
D.C. Power	4	Capacitor Bank Fuse = 1 I/O Turn On = 2, I/O Regulator = 1
Disk Channel	1	
1414C	1	

9.6.1.2 August

Unit	Errors	Comments
Core 0	0	
Core 1	0	
A.C.	0	
Console	0	
Drum	0	
SPU Channel	0	
Tape Channel 4	0	
Tape Channel 5	0	
D.C.	4	
MAU	0	
Flow Gating	1	
D.C. Power	3	I/O Regulator = 1 Bay 14F = 1 Bay 6R = 1
Drum Channel	1	
Tape Drives	2	Unit C = 1, Unit H = 1

9.6.1.3 September

Unit	Error	Comment
Core 0	0	
Core 1	2	
A.C.	1	
Console	0	
Disk Channel	0	
D.C.	1	
Power Supplies	1	+25 Bay 14 Front
1414D	1	
Tape Driver	2	Unit B = 1 Unit J = 1
Flow Gating	1	
1301	1	Power Drop Due to Overheating
Drum	0	
Tape Channel 4	0	
Tape Channel 5	0	
SPU Channel	0	
MAU	0	

L. L. Byers

9.6.1.4 Log Summaries

9.6.1.4.1 ILLIAC II Use

9.6.1.4.1.1 Summary of Use

Usage	July	August	September
A.E.C.	237.25	207.40	374.15
Scheduled Engineering	53.16	69.00	42.55
Unscheduled Engineering	31.23	18.55	19.55
Time Share Sign On and Run	86.35	147.40	103.50
Update and Development	1.30	12.15	6.40
Batch Processing (In house only)	27.00	22.05	15.40
Other In House Users	212.25	71.20	29.45
Demo.	1.20	3.00	2.00
Down Time	54.05	58.00	90.00
Unaccounted For Time	39.01	134.25	41.00
Total Time in Month	744.00	744.00	724.00

T. E. Kerkering

10. IBM 7094/1401 SERVICE, USE, AND PROGRAM DEVELOPMENT

(Supported in part by the National Science Foundation under Grant No. NSF-GP-700).

10.1 New Routines (7094)

F4-UOI-CEQ1-130-SR

Solution of Complex Linear Equations. This subroutine solves the system of complex linear equations (A+Bi)(X+Yi)=(C+Di) for the unknown vectors X and Y and the determinant of the matrix A+Bi, where A and B are the square matrices of real and imaginary coefficients respectively, and C and D are the vectors of real and imaginary constants respectively.

Programmed by W. D. Marquis
July 5, 1967

J5-UOI-CCP9-125-SR

CalComp Dimensioning Routine. This subroutine will draw dimension information, including arrows and size information, on the CalComp plotter. This program is based on a similar one called DIMENS in the CalComp SCOOP manual.

Programmed by J. T. Bagwell, Jr.
July 5, 1967

J5-UOI-CCP7-129-SR

Plot a Rectangle on the CalComp Plotter. The program draws rectangles of any size, at any angle, and in any position on the plotter paper. Adapted from the CalComp SCOOP routine RECT.

Adapted by J. T. Bagwell, Jr.
July 6, 1967

B3-UOI-EXP-126-SR — Floating Point Single Precision Exponential. This routine computes e^x, where e is the Napierian base and x is a floating point argument. EXP was originally programmed at the University of Chicago.

Revised by W. D. Marquis
July 10, 1967

I1-UOI-LSR1-132-SR — Program Selection. This subroutine selects the next program segment to be executed in a multiple core-load program. This program was adapted from a University of Michigan subroutine of the same name.

Revised by C. Hyde
July 10, 1967

J5-UOI-SETPLT-137-SR — Simplified Data Plotting on off-line printer. SETPLT is designed to relieve the user of the burden of calling the PLOT subroutine to plot sets of data points. SETPLT inspects the data to be plotted and executes a series of calls to PLOT to produce a graph on the printer. SETPLT originated in the Michigan Executive System.

Revised by P. A. Alsberg
July 10, 1967

C3-UOI-ERF1-68-SR — Floating Point Error Function and Floating Point Frequency Function. For a given floating point argument X this routine computes the following quantities:

1) Error function

$$\mathrm{ERF1}(X) = \frac{2}{\sqrt{\pi}} \int_0^X e^{-t^2}\, dt$$

2) Normal frequency function

$$\mathrm{ERF1FR}(X) = \frac{2}{\sqrt{\pi}} \int_{-\infty}^X e^{-t^2/2}\, dt$$

Revised by W. D. Marquis
July 11, 1967

10.2 New Routines (System/360)

D1-UOI-QUA1Z-3F-A Evaluation of One-Dimensional Definite Integrals by Mechanical Quadrature. The method was taken from the University of Illinois 7094 subroutine QUA1 written by Dr. John Ehrman.

Programmed David A. Ring
July 27, 1967

Q0-UOI-BEGIN-1M-A Program Starting Macro. This macro generates the code required at the beginning of an assembly language program control section.

Written by H. G. Friedman, Jr.
August 9, 1967

Q0-UOI-LEAVE-2M-A Program Termination Macro. This macro generates the code required for a program to reload the general registers and return to the calling program.

Written by H. G. Friedman, Jr.
August 15, 1967

10.3 Log Summaries

Table I - IBM 1401-II

Summary of Use

July, 1967

Scheduled Engineering		8:15
Unscheduled Engineering		16:10
Maintenance		6:07
7094 Preparation		531:43
List/Reproduce		36:20
Code Check		11:44
Tape Dump		4:08
ILLIAC II Preparation		4:00
Idle		44:43
	Total	663:10

Table II - IBM 1401-II

Summary of Machine Errors

July, 1967

1401 Main Frame		1
1402 Card Reader Punch		4
	Total	5

Table I - IBM 1401-IV

Summary of Use

July, 1967

Unscheduled Engineering		13:18
Maintenance		7:27
7094 Preparation		552:41
List/Reproduce		17:25
Code Check		7:15
Tape Dump		9:32
ILLIAC II Preparation		:10
Idle		31:49
	Total	639:37

Table II - IBM 1401-IV

Summary of Machine Errors

July, 1967

1402 Card Reader Punch		7
	Total	7

Table I - IBM 7094

Summary of Use

July, 1967

Scheduled Engineering				21:59
Unscheduled Engineering				20:07
Maintenance				4:13
Tape Test				12:30
Idle				7:55
Miscellaneous (Operator Training, tape rewind, system tape mounting, rerun of failing problems, tape skipping, destruction of clock reading)				103:06
TOTAL USE				
Training and Education			21:14	
University Administrative and Overhead Use			6:56	
System Modification and Improvement			26:24	
System Updating			1:35	
Customer Use				
In System		515:16		
Relinquish				
AGEC	1:12			
CE	:39			
Relinquish Total		1:51		
Special Short Shots		:54		
Customer Use Total			518:01	
		Total Use		574:10
		Total Time On		744:00

Table II - IBM 7094

Summary of Machine Errors

July, 1967

Tape Drives		5
Card Reader		2
Core		1
	Total	8

7094 Table III July, 1967

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
AAE	7	306	313	3	9	12	34.3	4 43.2	5 17.5
ACCY	0	113	113	0	2	2	0.0	1 8.2	1 8.2
ADV	0	16	16	0	3	3	0.0	1 13.6	1 13.6
AGE	0	168	168	0	5	5	0.0	2 7.6	2 7.6
AGEC	61	321	382	1	12	13	5.0	7 1.9	7 7.0
AGRON	175	125	300	1	15	16	47.5	1 46.4	2 34.0
ANS	0	142	142	0	6	6	0.0	3 12.1	3 12.1
ASTR	0	149	149	0	8	8	0.0	2 36.7	2 36.7
BECBS	0	50	50	0	2	2	0.0	1 17.9	1 17.9
BEDRE	0	8	8	0	1	1	0.0	19.0	19.0
BINRE	0	25	25	0	1	1	0.0	19.0	19.0
BOT	0	9	9	0	1	1	0.0	2.1	2.1
BOTAN	0	12	12	0	2	2	0.0	2.4	2.4
CCDME	0	25	25	0	2	2	0.0	45.0	45.0
CCSCS	0	7	7	0	1	1	0.0	7.9	7.9
CE	591	1905	2496	4	54	58	3 22.2	59 4.6	62 26.9
CHE	1	2122	2123	1	51	52	0.2	62 52.4	62 52.7
COMM	0	25	25	0	1	1	0.0	19.8	19.8
CP	0	33	33	0	2	2	0.0	5.2	5.2
CRC	0	93	93	0	1	1	0.0	2 12.0	2 12.0
CURLA	0	19	19	0	1	1	0.0	12.1	12.1
CZR	0	94	94	0	1	1	0.0	2 15.5	2 15.5
DCS	2768	304	3072	4	14	18	7 50.3	9 37.4	17 27.7
DNW	0	3	3	0	1	1	0.0	5.3	5.3
DOW	0	10	10	0	1	1	0.0	8.3	8.3
DS	0	293	293	0	5	5	0.0	10 56.5	10 56.5
DUE	0	1	1	0	1	1	0.0	0.2	0.2
ECON	0	269	269	0	9	9	0.0	1 29.4	1 29.4
ED	0	361	361	0	18	18	0.0	6 53.4	6 53.4
EDPSY	4	4	8	1	2	3	21.5	3.6	25.2
EE	293	633	926	4	21	25	50.6	12 12.5	12 3.2
ENTOM	0	19	19	0	2	2	0.0	11.9	11.9
FIN	0	1	1	0	1	1	0.0	0.4	0.4
FOR	0	20	20	0	2	2	0.0	17.2	17.2

7094 Table III July, 1967 Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
GENE	26	3	29	2	1	3	10.8	1.1	12.0
GEOG	0	9	9	0	1	1	0.0	2.3	2.3
GEOL	0	2	2	0	1	1	0.0	1.7	1.7
GSBA	153	31	184	3	1	4	2 33.4	35.0	3 8.5
HED	0	521	521	0	1	1	0.0	7 32.4	7 32.4
HONOR	0	5	5	0	1	1	0.0	9.5	9.5
HORT	0	13	13	0	2	2	0.0	7.7	7.7
ICR	0	141	141	0	3	3	0.0	10 9.2	10 9.2
IED	0	27	27	0	1	1	0.0	1 23.3	1 23.3
IGPA	0	13	13	0	1	1	0.0	8.9	8.9
ILR	0	3	3	0	1	1	0.0	0.6	0.6
INADM	0	9	9	0	1	1	0.0	50.9	50.9
IREC	0	148	148	0	4	4	0.0	3 0.4	3 0.4
LIBS	0	7	7	0	1	1	0.0	40.5	40.5
MATH	0	99	99	0	3	3	0.0	3 33.5	3 33.5
MATRL	0	744	744	0	22	22	0.0	12 26.9	12 26.9
MCBIO	0	20	20	0	1	1	0.0	6.7	6.7
ME	62	537	599	3	23	26	14.4	10 43.2	10 57.7
MMPE	0	139	139	0	5	5	0.0	46.1	46.1
MUSIC	93	70	163	1	1	2	1 54.2	1 37.4	3 31.7
NHS	0	101	101	0	1	1	0.0	2 2.0	2 2.0
NUCE	56	417	473	1	15	16	18.6	14 0.7	14 19.3
OIR	0	212	212	0	1	1	0.0	7 21.3	7 21.3
PEM	0	9	9	0	4	4	0.0	3 5.8	3 5.8
PEW	0	1	1	0	1	1	0.0	1.0	1.0
PHYB	0	221	221	0	7	7	0.0	2 9.7	2 9.7
PHYCS	1	1380	1381	1	18	19	0.4	48 2.6	48 3.1
PHYSL	0	75	75	0	4	4	0.0	28.1	28.1
PHYX	0	1546	1546	0	10	10	0.0	117 26.0	117 26.0
POLS	11	89	100	1	4	5	13.4	1 44.3	1 57.8
PSDEC	0	7	7	0	1	1	0.0	11.8	11.8
PSYCH	0	1619	1619	0	37	37	0.0	37 34.9	37 34.9
REC	0	26	26	0	2	2	0.0	46.3	46.3
SCONS	0	29	29	0	1	1	0.0	29.2	29.2
SGS	0	92	92	0	2	2	0.0	1 45.8	1 45.8
SOC	0	49	49	0	4	4	0.0	1 53.8	1 53.8

7094 Table III July, 1967 Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
SOCW	0	119	119	0	3	3	0.0	3 50.0	3 50.0
SPCH	0	34	34	0	3	3	0.0	43.1	43.1
SPED	0	49	49	0	2	2	0.0	46.1	46.1
SRL	0	47	47	0	1	1	0.0	1 40.5	1 40.5
SWS	0	471	471	0	22	22	0.0	8 50.3	8 50.3
TAM	11	545	556	1	19	20	2.4	7 57.2	7 59.7
VMS	0	1	1	0	1	1	0.0	0.2	0.2
VPH	0	60	60	0	1	1	0.0	31.1	31.1
VPP	0	36	36	0	1	1	0.0	10.3	10.3
VTED	104	48	152	1	3	4	1 53.6	1 39.4	3 33.0
WPGU	0	40	40	0	1	1	0.0	11.2	11.2
XSSS[3]	0	136	136	0	1	1	0.0	53.9	53.9
ZOOL	0	157	157	0	11	11	0.0	2 3.2	2 3.2
Subtotal	4417	17833	22250	33	513	546	21 13.7	518 .5	539 14.3
DCSSY[4]	0	1924	1924	0	19	19	0.0	26 24.4	26 24.4
XDCS[5]	0	41	41	0	1	1	0.0	1 35.1	1 35.1
SSUAD[6]	0	235	235	0	1	1	0.0	6 55.9	6 55.9
Total	4417	20033	24450	33	534	567	21 13.7	552 55.9	574 9.7

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
4 System Improvement and Modifications
5 System Updating
6 University Administrative Overhead Use

Table I - IBM 1401-II

Summary of Use

August, 1967

Scheduled Engineering		6:50
Unscheduled Engineering		11:40
Maintenance		6:27
7094 Preparation		554:09
List/Reproduce		15:23
Code Check		6:57
Tape Dump		2:50
1604 Preparation		:18
ILLIAC II Preparation		1:43
Idle		75:14
	Total	681:31

Table II - IBM 1401-II

Summary of Machine Errors

August, 1967

1402 Card Reader Punch		3
729V Tape Drives		3
	Total	6

Table I - IBM 1401-IV

Summary of Use

August, 1967

Scheduled Engineering		4:10
Unscheduled Engineering		12:33
Maintenance		7:43
7094 Preparation		581:37
List/Reproduce		15:39
Code Check		12:47
Tape Dump		6:31
1604 Preparation		:15
ILLIAC II Preparation		1:33
Idle		32:58
	Total	675:46

Table II - IBM 1401-IV

Summary of Machine Errors

August, 1967

1401 Main Frame		3
1402 Card Reader Punch		3
1403 Printer		2
	Total	8

Table I - IBM 7094

Summary of Use

August, 1967

Scheduled Engineering			12:26
Unscheduled Engineering			2:48
Maintenance			6:05
Air Conditioning			4:21
Idle			22:16
Miscellaneous (Operator training, system tape mounting, rerun of failing problems)			98:02
Total Use			
Training and Education		16:49	
University Administrative Overhead Use		24:39	
System Modification and Improvement		25:09	
System Updating		2:56	
Customer Use			
In System	501:11		
Relinquish	8:14		
Special Short Shots	:26		
Customer Use Total		509:51	
	Total Use		579:24
	Total Time On		725:22

Table II - IBM 7094

Summary of Errors

August, 1967

Disk		2
Tape Drives		1
	Total	3

Table I - IBM 360/50

Summary of Use

August, 1967

Scheduled Engineering			15:08
Unscheduled Engineering			31:20
Maintenance			1:15
Power Failure			1:50
Miscellaneous (Idle, operator training, system mounting, rerun of failing problems)			133:45
Total Use			
Training and Education		14:17	
University Administrative Overhead Use		:03	
System Modification, Improvement, and Updating		130:54	
Customer Use			
In System	83:36		
Special Short Shots	1:10		
Customer Use Total		84:46	
Total Use			230:00
Total Time On			413:18

Table II - IBM 360/50

Summary of Errors

August, 1967

Punch	3
Disk Unit	3
Core	1
CPU	6
Total	13

7094 Table III August, 1967

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
AAE	75	195	270	1	6	7	1 45.8	3 33.8	5 19.7
ACCY	0	43	43	0	3	3	0.0	1 35.6	1 35.6
ADV	0	11	11	0	2	2	0.0	37.0	37.0
AGE	0	369	369	0	6	6	0.0	7 32.0	7 32.0
AGEC	83	180	263	1	11	12	42.6	10 41.8	11 24.4
AGRON	57	167	224	1	15	16	35.8	2 18.9	2 54.8
ANS	0	140	140	0	5	5	0.0	1 53.5	1 53.5
ASTR	0	96	96	0	5	5	0.0	1 18.7	1 18.7
BECBS	0	15	15	0	2	2	0.0	5 39.1	5 39.1
BEDRE	0	50	50	0	1	1	0.0	2 2.0	2 2.0
BINRE	0	19	19	0	1	1	0.0	10.9	10.9
BIOPH	0	4	4	0	1	1	0.0	15.9	15.9
BOT	0	6	6	0	1	1	0.0	2.6	2.6
BOTAN	0	3	3	0	1	1	0.0	0.5	0.5
CCDME	0	66	66	0	1	1	0.0	7 16.0	7 16.0
CCSCS	0	2	2	0	1	1	0.0	2.3	2.3
CE	245	1582	1827	4	48	52	2 33.0	55 12.7	57 45.7
CHE	0	2130	2130	0	53	53	0.0	59 16.8	59 16.8
CP	0	46	46	0	2	2	0.0	14.6	14.6
CRC	0	158	158	0	1	1	0.0	3 39.5	3 39.5
CURLA	0	52	52	0	1	1	0.0	24.6	24.6
CZR	0	120	120	0	1	1	0.0	6 29.2	6 29.2
DCS	919	213	1132	4	11	15	3 51.8	4 55.7	8 47.6
DOW	0	22	22	0	1	1	0.0	39.7	39.7
DS	0	151	151	0	5	5	0.0	7 24.0	7 24.0
ECON	0	147	147	0	5	5	0.0	1 26.3	1 26.3
ED	0	229	229	0	11	11	0.0	5 20.1	5 20.1
EDPSY	6	16	22	2	2	4	20.8	8.4	29.2
EE	73	736	809	4	22	26	25.8	13 48.7	14 14.6
ENGAD	0	3	3	0	1	1	0.0	0.1	0.1
ENGCS	0	2	2	0	1	1	0.0	0.8	0.8
ENTOM	0	18	18	0	1	1	0.0	11.9	11.9
FIN	0	2	2	0	1	1	0.0	1.1	1.1
FOR	0	23	23	0	1	1	0.0	1 50.7	1 50.7

7094 Table III August, 1967 Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
FT	0	6	6	0	1	1	0.0	8.5	8.5
GENE	4	12	16	2	1	3	1.0	2.9	3.9
GEOG	0	26	26	0	2	2	0.0	5.7	5.7
GEOL	0	5	5	0	1	1	0.0	18.1	18.1
GSBA	172	30	202	2	1	3	1 53.8	36.3	2 30.2
HEC	0	18	18	0	2	2	0.0	27.8	27.8
HED	0	62	62	0	1	1	0.0	6.1	6.1
HLTHS	0	1	1	0	1	1	0.0	1.2	1.2
HONOR	0	9	9	0	1	1	0.0	2.9	2.9
HORT	0	7	7	0	2	2	0.0	4.4	4.4
ICR	0	59	59	0	3	3	0.0	4 11.8	4 11.8
IE	3	0	3	1	0	1	0.7	0.0	0.7
IED	0	3	3	0	1	1	0.0	0.5	0.5
IGPA	0	5	5	0	1	1	0.0	4.3	4.3
INADM	0	2	2	0	1	1	0.0	2.0	2.0
IREC	0	88	88	0	3	3	0.0	1 52.2	1 52.2
LIBS	0	9	9	0	2	2	0.0	22.1	22.1
MATH	0	40	40	0	2	2	0.0	1 31.9	1 31.9
MATRL	0	826	826	0	24	24	0.0	12 13.0	12 13.0
MCBIO	0	2	2	0	1	1	0.0	0.7	0.7
ME	10	491	501	2	18	20	3.9	8 12.7	8 16.7
MKTG	0	12	12	0	1	1	0.0	20.8	20.8
MMPE	0	158	158	0	5	5	0.0	4 42.5	4 42.5
MUSIC	38	30	68	1	1	2	1 7.3	29.2	1 36.5
NHS	0	367	367	0	3	3	0.0	9 4.9	9 4.9
NUCE	22	672	694	1	14	15	6.1	35 44.0	35 50.2
OAC	0	3	3	0	1	1	0.0	7.6	7.6
OIR	0	295	295	0	1	1	0.0	7 13.9	7 13.9
PEM	0	1	1	0	1	1	0.0	0.2	0.2
PHYB	0	254	254	0	5	5	0.0	3 5.4	3 5.4
PHYCS	0	923	923	0	16	16	0.0	30 9.7	30 9.7
PHYSL	0	102	102	0	4	4	0.0	37.3	37.3
PHYX	0	1753	1753	0	8	8	0.0	101 9.2	101 9.2
POLS	61	166	227	2	7	9	3 19.1	4 19.7	7 38.8
PSYCH	0	1705	1705	0	36	36	0.0	35 8.3	35 8.3
REC	0	23	23	0	2	2	0.0	25.0	25.0

7094 Table III August, 1967 Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
SCONS	0	76	76	0	1	1	0.0	1 10.1	1 10.1
SGS	0	132	132	0	2	2	0.0	2 52.7	2 52.7
SOC	0	136	136	0	4	4	0.0	8 17.2	8 17.2
SOCW	0	80	80	0	2	2	0.0	3 20.6	3 20.6
SPCH	0	22	22	0	4	4	0.0	23.6	23.6
SPED	0	4	4	0	2	2	0.0	40.7	40.7
SRL	0	17	17	0	1	1	0.0	7.0	7.0
SWS	0	663	663	0	17	17	0.0	11 20.8	11 20.8
TAM	2	537	539	1	17	18	0.4	6 3.4	6 3.8
VPH	0	28	28	0	1	1	0.0	40.1	40.1
VPP	0	30	30	0	1	1	0.0	9.5	9.5
VTED	0	64	64	0	2	2	0.0	1 31.1	1 31.1
WPGU	0	20	20	0	1	1	0.0	11.6	11.6
XSSS[3]	0	82	82	0	1	1	0.0	26.2	26.2
ZOOL	0	183	183	0	9	9	0.0	3 24.2	3 24.2
Subtotal	1770	17228	18998	29	469	498	16 48.6	509 52.5	526 41.1
DCSSY[4]	0	1205	1205	0	17	17	0.0	25 8.8	25 8.8
XDCS[5]	0	63	63	0	1	1	0.0	2 55.6	2 55.6
SSUAD[6]	0	376	376	0	2	2	0.0	24 38.9	24 38.9
Total	1770	18872	20642	29	489	518	16 48.6	562 35.8	579 24.4

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
4 System Improvement and Modifications
5 System Updating
6 University Administrative Overhead Use

IBM 360/50 Table III August, 1967

Dept[1]	Number of Runs T and E[2]	Number of Runs Res	Number of Runs Total	Number of Specs T and E[2]	Number of Specs Res	Number of Specs Total	Usage in Hours-Minutes T and E[2]	Usage in Hours-Minutes Res	Usage in Hours-Minutes Total
AAE	62	4	66	1	1	2	5 5.3	14.8	5 20.2
ACCY	166	10	176	1	1	2	6 41.1	2 21.2	9 2.3
AGE	0	10	10	0	1	1	0.0	5.6	5.6
AGEC	0	3	3	0	1	1	0.0	10.9	10.9
AGRON	14	0	14	1	0	1	17.7	0.0	17.7
CCDME	0	17	17	0	1	1	0.0	1 3.1	1 3.1
CE	0	109	109	0	3	3	0.0	12 11.1	12 11.1
CHE	36	61	97	1	5	6	1 0.7	3 10.6	4 11.3
CRC	0	10	10	0	2	2	0.0	15.8	15.8
DCS	30	435	465	1	3	4	50.7	36 37.1	37 27.9
ECON	0	14	14	0	1	1	0.0	54.5	54.5
EE	0	5	5	0	1	1	0.0	7.6	7.6
ENGAD	0	46	46	0	1	1	0.0	3 1.1	3 1.1
ENGCS	0	14	14	0	1	1	0.0	1 15.8	1 15.8
GSBA	10	0	10	1	0	1	20.6	0.0	20.6
MATRL	0	34	34	0	1	1	0.0	1 30.6	1 30.6
NUCE	0	6	6	0	1	1	0.0	10.4	10.4
PHYB	0	7	7	0	2	2	0.0	12.8	12.8
PHYCS	0	88	88	0	3	3	0.0	5 41.6	5 41.6
PHYSL	0	8	8	0	1	1	0.0	31.3	31.3
PHYX	0	151	151	0	4	4	0.0	6 49.6	6 49.6
POLS	0	24	24	0	1	1	0.0	1 14.0	1 14.0
PSYCH	0	42	42	0	2	2	0.0	1 35.0	1 35.0
SGS	0	3	3	0	1	1	0.0	8.1	8.1
SWS	0	57	57	0	2	2	0.0	2 52.1	2 52.1
XSSS[3]	0	52	52	0	1	1	0.0	1 10.3	1 10.3
ZOOL	0	46	46	0	2	2	0.0	1 19.7	1 19.7
Subtotal	318	1256	1574	6	43	49	14 16.5	84 46.1	99 2.6
DCSSY[4]	0	952	952	0	12	12	0.0	130 54.4	130 54.4
SSUAD[5]	0	5	5	0	1	1	0.0	3.2	3.2
Total	318	2213	2531	6	56	62	14 16.5	215 43.7	230 0.2

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
5 University Administrative Overhead Use

Table I - IBM 1401-II

Summary of Use

September, 1967

Scheduled Engineering		6:00
Unscheduled Engineering		2:45
Maintenance		4:55
7094 Preparation		434:51
List/Reproduce		25:27
Code Check		16:09
Tape Dump		:28
ILLIAC II Preparation		3:55
Idle		89:30
	Total	584:00

Table II - IBM 1401-II

Summary of Machine Errors

September, 1967

1402 Card Reader Punch		2
1403 Printer		1
	Total	3

Table I - IBM 1401-IV

Summary of Use

September, 1967

Scheduled Engineering	6:06
Unscheduled Engineering	9:34
Maintenance	6:05
7094 Preparation	474:56
List/Reproduce	18:51
Code Check	11:50
Tape Dump	1:27
ILLIAC Preparation	2:31
Idle	56:15
Total	587:35

Table II - IBM 1401-IV

Summary of Machine Errors

September, 1967

1402 Card Reader Punch	3
Total	3

Table I - IBM 7094

Summary of Use

September, 1967

Scheduled Engineering			22:58
Unscheduled Engineering			7:20
Maintenance			5:13
Air Conditioning			16:40
Power Failure			1:54
Tape Test			:40
Idle			33:59
Miscellaneous (Operator training, tape rewind, system tape mounting, rerun of failing problems)			63:02
Total Use			
Training and Education		4:15	
University Administrative Overhead Use		11:17	
Institutional Cooperation Program		10:10	
System Modification and Improvement		11:33	
System Updating		1:04	
Customer Use			
In System	397:15		
Relinquish	7:32		
Special Short Shots	:22		
Customer Use Total		405:09	
	Total Use		443:28
	Total Time On		595:14

Table II - IBM 7094

Summary of Errors

September, 1967

System	1
Punch	1
Disk	1
Tape Drive	1
CPU	1
Printer	1
Total	6

Table I - IBM 360/50

Summary of Use

September, 1967

Scheduled Engineering			5:05
Unscheduled Engineering			5:13
Miscellaneous (Operator training, system tape mounting, rerun of failing problems, idle)			86:07
Total Use			
Training and Education		41:49	
University Administrative Overhead Use		1:19	
System Modification, Improvement, and Updating		121:24	
Customer Use			
In System	49:23		
Special Short Shots	2:53		
Customer Use Total		52:16	
	Total Use		216:48
	Total Time On		313:13

Table II - IBM 360/50

Summary of Errors

September, 1967

Disk		3
CPU		2
Printer		1
	Total	6

7094 Table III September, 1967

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
AAE	32	33	65	3	3	6	27.2	28.9	56.2
ACCY	22	8	30	1	2	3	32.2	10.3	42.5
ADV	0	7	7	0	1	1	0.0	17.5	17.5
AGE	0	277	277	0	6	6	0.0	2 16.6	2 16.6
AGEC	1	133	134	1	12	13	0.0	11 6.7	11 6.8
AGRON	44	175	219	2	16	18	9.9	2 33.8	2 43.7
ANS	0	91	91	0	5	5	0.0	2 49.4	2 49.4
ANTH	4	0	4	1	0	1	2.2	0.0	2.2
ASTR	0	91	91	0	8	8	0.0	1 4.4	1 4.4
BECBS	0	13	13	0	2	2	0.0	19.7	19.7
BEDRE	0	2	2	0	2	2	0.0	15.7	15.7
BINRE	0	2	2	0	1	1	0.0	0.2	0.2
BIOPH	0	26	26	0	1	1	0.0	1 21.0	1 21.0
BOT	0	1	1	0	1	1	0.0	0.2	0.2
CCDME	0	17	17	0	1	1	0.0	23.5	23.5
CE	75	1030	1105	4	41	45	14.7	51 21.1	51 26.9
CHE	0	1454	1454	0	51	51	0.0	57 11.2	57 11.2
CP	0	14	14	0	2	2	0.0	5.5	5.5
CRC	0	36	36	0	1	1	0.0	2 17.8	2 17.8
CURLA	0	19	19	0	1	1	0.0	8.9	8.9
CZR	0	27	27	0	1	1	0.0	1 48.2	1 48.2
DCS	108	166	274	3	9	12	46.3	3 14.9	4 1.3
DOW	0	28	28	0	1	1	0.0	18.5	18.5
DS	0	153	153	0	3	3	0.0	28 0.4	28 0.4
ECON	0	36	36	0	5	5	0.0	39.9	39.9
ED	0	50	50	0	9	9	0.0	1 7.6	1 7.6
EDPSY	20	5	25	2	1	3	4.9	14.8	19.7
EDTES	0	7	7	0	1	1	0.0	3.3	3.3
EE	11	466	477	2	21	23	3.0	10 13.7	10 16.7
FIN	0	2	2	0	1	1	0.0	0.8	0.8
FOR	0	28	28	0	1	1	0.0	17.9	17.9
FT	0	7	7	0	1	1	0.0	7.7	7.7
GEOG	8	0	8	1	0	1	0.8	0.0	0.8
GEOL	1	2	3	1	1	2	4.0	5.3	9.4

7094 Table III September, 1967 Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
GSBA	6	0	6	2	0	2	7.1	0.0	7.1
HEC	0	11	11	0	1	1	0.0	42.8	42.8
HED	0	59	59	0	1	1	0.0	1 59.9	1 59.9
HORT	0	15	15	0	2	2	0.0	28.5	28.5
ICR	0	34	34	0	2	2	0.0	39.1	39.1
IE	7	0	7	1	0	1	1.3	0.0	1.3
IED	0	4	4	0	1	1	0.0	6.9	6.9
ILR	0	51	51	0	2	2	0.0	1 11.2	1 11.2
INADM	0	14	14	0	1	1	0.0	11.2	11.2
IREC	0	27	27	0	1	1	0.0	17.8	17.8
LIBS	0	3	3	0	1	1	0.0	1 18.1	1 18.1
MATH	0	26	26	0	2	2	0.0	29.2	29.2
MATRL	0	524	524	0	22	22	0.0	9 42.8	9 42.8
ME	195	431	626	5	28	33	39.5	9 13.0	9 52.6
MKTG	0	32	32	0	1	1	0.0	47.8	47.8
MMPE	0	89	89	0	4	4	0.0	2 14.8	2 14.8
MUSIC	0	1	1	0	1	1	0.0	0.9	0.9
NHS	0	139	139	0	2	2	0.0	5 4.1	5 4.1
NUCE	4	722	726	1	15	16	0.9	12 57.1	12 58.0
OAC	0	14	14	0	1	1	0.0	1 4.2	1 4.2
OIR	0	124	124	0	1	1	0.0	8 22.7	8 22.7
PEW	0	5	5	0	1	1	0.0	4.7	4.7
PHYB	0	98	98	0	5	5	0.0	1 30.9	1 30.9
PHYCS	11	742	753	1	16	17	2.1	21 15.2	21 17.3
PHYSL	0	72	72	0	3	3	0.0	28.9	28.9
PHYX	0	1654	1654	0	8	8	0.0	107 2.0	107 2.0
POLS	24	37	61	1	5	6	59.0	4 41.5	5 40.6
PSYCH	0	449	449	0	18	18	0.0	9 43.4	9 43.4
REC	0	15	15	0	2	2	0.0	40.4	40.4
SCONS	0	68	68	0	1	1	0.0	1 43.0	1 43.0
SGS	0	105	105	0	2	2	0.0	1 50.8	1 50.8
SHCBR	0	16	16	0	1	1	0.0	16.0	16.0
SOC	0	63	63	0	3	3	0.0	1 51.4	1 51.4
SOCW	0	52	52	0	2	2	0.0	2 7.1	2 7.1
SPCH	0	12	12	0	1	1	0.0	10.1	10.1
SPED	0	9	9	0	2	2	0.0	1 8.5	1 8.5

7094 Table III September, 1967 Continued

Dept[1]	Number of Runs T and E[2]	Number of Runs Res	Number of Runs Total	Number of Specs T and E[2]	Number of Specs Res	Number of Specs Total	7094 Usage in Hours-Minutes T and E[2]	7094 Usage in Hours-Minutes Res	7094 Usage in Hours-Minutes Total
SRL	0	4	4	0	1	1	0.0	0.8	0.8
SSU	0	7	7	0	1	1	0.0	4.5	4.5
SWS	0	279	279	0	17	17	0.0	8 30.1	8 30.1
TAM	0	223	223	0	12	12	0.0	2 36.1	2 36.1
VPH	0	20	20	0	1	1	0.0	46.3	46.3
VPP	0	21	21	0	1	1	0.0	7.2	7.2
VTED	0	11	11	0	1	1	0.0	3.2	3.2
WPGU	0	7	7	0	1	1	0.0	9.3	9.3
XSSS[3]	0	67	67	0	1	1	0.0	21.7	21.7
ZOOL	0	72	72	0	6	6	0.0	41.2	41.2
Subtotal	573	10834	11407	32	413	445	4 16.1	405 7.5	409 23.7
DCSSY[4]	0	713	713	0	14	14	0.0	11 32.9	11 32.9
XDCS[5]	0	37	37	0	1	1	0.0	1 4.4	1 4.4
SSUAD[6]	0	299	299	0	2	2	0.0	11 16.9	11 16.9
ICP[7]	0	0	0	0	0	0	0.0	10 10.0	10 10.0
Total	573	11883	12456	32	430	462	4 16.1	439 11.7	443 27.9

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
4 System Improvement and Modifications
5 System Updating
6 University Administrative Overhead Use
7 Institutional Cooperation Program

IBM 360/50 Table III September, 1967

Dept[1]	Number of Runs			Number of Specs			Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
AAE	136	1	137	3	1	4	11 37.2	1.6	11 38.9
ACCY	12	0	12	1	0	1	1 23.8	0.0	1 23.8
AGRON	0	2	2	0	1	1	0.0	8.0	8.0
CE	78	44	122	2	3	5	1 29.6	4 21.6	5 51.3
CHE	18	25	43	3	6	9	31.1	1 6.7	1 37.8
CRC	0	2	2	0	1	1	0.0	1.1	1.1
DCS	1514	380	1894	5	4	9	26 26.8	20 45.8	47 12.6
ECON	0	8	8	0	1	1	0.0	31.8	31.8
EE	0	10	10	0	1	1	0.0	12.1	12.1
ENGAD	0	21	21	0	1	1	0.0	59.6	59.6
ENGCS	0	42	42	0	1	1	0.0	4 47.0	4 47.0
ENGH	1	0	1	1	0	1	0.1	0.0	0.1
GSBA	6	0	6	1	0	1	13.0	0.0	13.0
MATRL	0	11	11	0	1	1	0.0	1 30.1	1 30.1
NUCE	10	6	16	2	1	3	7.3	8.9	16.3
PHYCS	0	93	93	0	4	4	0.0	8 48.8	8 48.8
PHYX	0	100	100	0	4	4	0.0	3 23.0	3 23.0
POLS	0	1	1	0	1	1	0.0	8.3	8.3
SGS	0	5	5	0	1	1	0.0	7.5	7.5
SWS	0	18	18	0	2	2	0.0	1 50.2	1 50.2
XSSS[3]	0	66	66	0	1	1	0.0	2 53.0	2 53.0
ZOOL	0	13	13	0	2	2	0.0	28.7	28.7
Subtotal	1775	848	2623	18	37	55	41 49.4	52 15.1	94 4.5
DCSSY[4]	0	732	732	0	17	17	0.0	121 24.2	121 24.2
SSUAD[5]	0	26	26	0	1	1	0.0	1 19.0	1 19.0
Total	1775	1606	3381	18	55	73	41 49.4	174 58.3	216 47.7

1 See list of department codes following
2 Training and Education
3 Special Short Shots
4 System Improvement and Modifications
5 University Administrative Overhead Use

Quarterly Summary of Departmental Running Time

July, August, September 1967

Dept[1]	Number of Runs T and E[2]	Res	Total	Number of Specs T and E[2]	Res	Total	7094 Usage in Hours-Minutes T and E[2]	Res	Total
AAE	114	534	648	7	18	25	2 47.4	8 46.1	11 33.5
ACCY	22	164	186	1	7	8	32.2	2 54.2	3 26.5
ADV	0	34	34	0	6	6	0.0	2 8.2	2 8.2
AGE	0	814	814	0	17	17	0.0	11 56.3	11 56.3
AGEC	145	634	779	3	35	38	47.8	28 50.5	29 38.3
AGRON	276	467	743	4	46	50	1 33.4	6 39.2	8 12.6
ANS	0	373	373	0	16	16	0.0	7 55.1	7 55.1
ANTH	4	0	4	1	0	1	2.2	0.0	2.2
ASTR	0	336	336	0	21	21	0.0	5 0.0	5 0.0
BECBS	0	78	78	0	6	6	0.0	7 16.9	7 16.9
BEDRE	0	60	60	0	4	4	0.0	2 36.8	2 36.8
BINRE	0	46	46	0	3	3	0.0	30.1	30.1
BIOPH	0	30	30	0	2	2	0.0	1 37.0	1 37.0
BOT	0	16	16	0	3	3	0.0	5.0	5.0
BOTAN	0	6	6	0	2	2	0.0	0.8	0.8
CCDME	0	108	108	0	4	4	0.0	8 24.6	8 24.6
CCSCS	0	9	9	0	2	2	0.0	10.3	10.3
CE	911	4517	5428	12	143	155	6 10.1	165 29.5	171 39.6
CHE	1	5706	5707	1	155	156	0.2	179 20.5	179 20.8
COMM	0	25	25	0	1	1	0.0	19.8	19.8
CP	0	93	93	0	6	6	0.0	25.4	25.4
CRC	0	287	287	0	3	3	0.0	8 9.4	8 9.4
CURLA	0	63	63	0	3	3	0.0	45.7	45.7
CZR	0	241	241	0	3	3	0.0	10 33.1	10 33.1
DCS	3795	683	4478	11	34	45	12 28.6	17 48.2	30 16.8
DNW	0	3	3	0	1	1	0.0	5.3	5.3
DOW	0	60	60	0	3	3	0.0	1 6.7	1 6.7
DS	0	597	597	0	13	13	0.0	46 21.0	46 21.0
DUE	0	1	1	0	1	1	0.0	0.2	0.2
ECON	0	452	452	0	19	19	0.0	3 35.8	3 35.8
ED	0	639	639	0	37	37	0.0	13 20.7	13 20.7
EDPSY	30	25	55	5	5	10	47.3	26.9	1 14.2
EDTES	0	7	7	0	1	1	0.0	3.3	3.3
EE	377	1835	2212	10	64	74	1 19.5	36 15.1	37 34.6

Quarterly Summary of Departmental Running Time

July, August, September 1967 Continued

Dept[1]	Number of Runs: T and E[2]	Number of Runs: Res	Number of Runs: Total	Number of Specs: T and E[2]	Number of Specs: Res	Number of Specs: Total	7094 Usage in Hours-Minutes: T and E[2]	7094 Usage in Hours-Minutes: Res	7094 Usage in Hours-Minutes: Total
ENGAD	0	3	3	0	1	1	0.0	0.1	0.1
ENGCS	0	2	2	0	1	1	0.0	0.8	0.8
ENTOM	0	37	37	0	3	3	0.0	23.9	23.9
FIN	0	5	5	0	3	3	0.0	2.5	2.5
FOR	0	71	71	0	4	4	0.0	2 25.9	2 25.9
FT	0	13	13	0	2	2	0.0	16.3	16.3
GENE	30	15	45	4	2	6	11.8	4.1	16.0
GEOG	8	35	43	1	3	4	0.8	8.0	8.9
GEOL	1	9	10	1	3	4	4.0	25.2	29.3
GSBA	331	61	392	7	2	9	4 34.5	1 11.4	5 46.0
HEC	0	29	29	0	3	3	0.0	1 10.7	1 10.7
HED	0	642	642	0	3	3	0.0	9 38.5	9 38.5
HLTHS	0	1	1	0	1	1	0.0	1.2	1.2
HONOR	0	14	14	0	2	2	0.0	12.5	12.5
HORT	0	35	35	0	6	6	0.0	40.8	40.8
ICR	0	234	234	0	8	8	0.0	15 0.2	15 0.2
IE	10	0	10	2	0	2	2.0	0.0	2.0
IED	0	34	34	0	3	3	0.0	1 30.8	1 30.8
IGPA	0	18	18	0	2	2	0.0	13.3	13.3
ILR	0	54	54	0	3	3	0.0	1 11.9	1 11.9
INADM	0	25	25	0	3	3	0.0	1 4.2	1 4.2
IREC	0	263	263	0	8	8	0.0	5 10.5	5, 10.5
LIBS	0	19	19	0	4	4	0.0	2 20.8	2 20.8
MATH	0	165	165	0	7	7	0.0	5 34.7	5 34.7
MATRL	0	2094	2094	0	68	68	0.0	34 22.9	34 22.9
MCBIO	0	22	22	0	2	2	0.0	7.4	7.4
ME	267	1459	1726	10	69	79	58.0	28 9.0	29 7.0
MKTG	0	44	44	0	2	2	0.0	1 8.6	1 8.6
MMPE	0	386	386	0	14	14	0.0	7 43.6	7 43.6
MUSIC	131	101	232	2	3	5	3 1.5	2 7.6	5 9.2
NHS	0	607	607	0	6	6	0.0	16 11.2	16 11.2
NUCE	82	1811	1893	3	44	47	25.7	62 41.9	63 7.7
OAC	0	17	17	0	2	2	0.0	1 11.8	1 11.8
OIR	0	631	631	0	3	3	0.0	22 58.0	22 58.0
PEM	0	10	10	0	5	5	0.0	3 6.0	3 6.0
PEW	0	6	6	0	2	2	0.0	5.7	5.7
PHYP	0	573	573	0	17	17	0.0	6 46.1	6 46.1

July, August, September 1967 Continued

Dept[1]	Number of Runs T and E[2]	Res	Total	Number of Specs T and E[2]	Res	Total	7094 Usage in Hours-Minutes T and E[2]	Res	Total
PHYX	0	5053	5053	0	26	26	0.0	325 37.2	325 37.2
PHYSL	0	249	249	0	11	11	0.0	1 34.4	1 34.4
POLS	96	292	388	4	16	20	4 31.6	10 45.7	15 17.3
PSDEC	0	7	7	0	1	1	0.0	11.8	11.8
PSYCH	0	3773	3773	0	91	91	0.0	82 26.8	82 26.8
REC	0	64	64	0	6	6	0.0	1 51.7	1 51.7
SCONS	0	173	173	0	3	3	0.0	3 22.5	3 22.5
SGS	0	329	329	0	6	6	0.0	6 29.5	6 29.5
SHCBR	0	16	16	0	1	1	0.0	16.0	16.0
SOC	0	248	248	0	11	11	0.0	12 2.4	12 2.4
SOCW	0	251	251	0	7	7	0.0	9 17.9	9 17.9
SPCH	0	68	68	0	8	8	0.0	1 17.0	1 17.0
SPED	0	62	62	0	6	6	0.0	2 35.3	2 35.3
SRL	0	68	68	0	3	3	0.0	1 48.4	1 48.4
SSU	0	7	7	0	1	1	0.0	4.5	4.5
SWS	0	1413	1413	0	56	56	0.0	28 41.3	28 41.3
TAM	13	1305	1318	2	48	50	2.8	16 36.8	16 39.7
VMS	0	1	1	0	1	1	0.0	0.2	0.2
VPH	0	108	108	0	3	3	0.0	1 57.7	1 57.7
VPP	0	87	87	0	3	3	0.0	27.1	27.1
VTED	104	123	227	1	6	7	1 53.6	3 13.7	5 7.4
WFGU	0	67	67	0	3	3	0.0	32.2	32.2
XSSS[3]	0	285	285	0	3	3	0.0	1 41.9	1 41.9
ZOOL	0	412	412	0	26	26	0.0	6 8.8	6 8.8
Subtotal	6760	45894	52654	94	1394	1488	42 18.6	1432 59.8	1475 18.5
DCSSY[4]	0	3842	3842	0	50	50	0.0	63 6.2	63 6.2
XDCS[5]	0	141	141	0	3	3	0.0	5 35.2	5 35.2
SSUAD[6]	0	910	910	0	5	5	0.0	42 51.8	42 51.8
ICP[7]	0	0	0	0	0	0	0.0	10 10.0	10 10.0
Total	6760	50787	57547	94	1452	1546	42 18.6	1554 43.0	1597 1.7

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
4 System Improvement and Modifcations
5 System Updating
6 University Administrative Overhead Use
7 Institutional Cooperation Program

11. PROBLEM SPECIFICATIONS

11.1 Research Problem Specifications

During the third quarter of 1967, 117 problem specifications were submitted to the Department for computation. The following brief descriptions of these problems have been prepared for inclusion in this report by those submitting them. T indicates a calculation associated with a thesis.

2696-77001 Mining, Metallurgy, and Petroleum Engineering. Porous Media Graphs. The characteristics of fluid flows through porous media or the characteristics of river networks may be represented by their heights or storeys. The vertex of springs is denoted by zero and each junction of two "rivers" is denoted by one. Obviously, the number of the junctions is one less than that of the vertices. One can use Monte Carlo method to randomly generate satisfactorily enough sets of n zeros and n-1 ones, and from these one can use the computer program to find the distribution function of heights for these networks of order n. Finally, from the distribution functions one can calculate the expection value for the networks of order n. (A. E. Scheidegger)

2697-77002 T Mechanical Engineering. Unsteady Heat Transfer for Laminar Flow Over a Flat Plate. The thermal response of a laminar boundry-layer over a flat plate due to step change in temperature and step change in flux is investigated. Incompressible flow is considered first and solutions for the wall flux variation and wall temperature variation for the step change in temperature and flux respectively are found. (L. S. Cheema)

2698-77003 Special Education, Decatur Public Schools. Role Perception of Illinois School Psychologists. The study is concerned with the analysis of the multiple roles of school psychologists employed by the public schools in Illinois. The specific purposes of the investigation are to ascertain the role expectations of school psychologists, performances, attributes, and participations as perceived by Illinois school psychologists and directors of special education. General descriptive statistics such as frequency distributions and percentages and chi-square are used in the analysis. A SSUPAC system program is used. (James Tan)

2699-77007 T Physical Education for Men and Graduate PE. Effects of Brief Running Program on Physical Fitness Tests. This study was conducted to determine the effects of a brief run-walk program incorporated into a Basic Movement course on a select battery of cardiovascular and physical fitness tests. The subjects were 71 female college freshmen enrolled in one of four Basic Movement classes. They were given a battery of seven tests at the beginning of the semester and again at the end of the semester. There was an experimantal group (32 subjects) which participated in the run-walk program the last 10 minutes of their class time, and a control group (39 students) who participated in the regular class activities. The computer will perform an F ratio on the pre-tests of the control and experimental groups; a correlated t test on the pre- and post-tests within each group; and an uncorrelated t test between the mean differences between pre- and post-tests between the groups. Also means and standard deviations will be reported on each test by the computer. The results will be used to show if significant improvement occurred within each group, and if the experimental group improved significantly more than the control group in any of the tests. (M. Hornyak)

2700-77011 Mechanical Engineering. System-Component Design-Analysis. This problem is primarily concerned with the development of computer programs for supplementing class lectures and student projects in machine design courses at the University of Illinois. Programs to aid in the design and analysis of such components as gears, shafts, bearings, clutches and brakes will be developed and integrated to facilitate their widest possible use with other instructional media. (D. H. Offner)

2701-77012 T Chemistry and Chemical Engineering. Electrochemical Kinetic Studies of the Nickel-Tin and Platinum-Tin Systems. Experimental values of current and potential will be measured by polarography, cyclic voltammetry and chronopotentiometry. The computer will calculate theoretical values of the current and potential and compare these values to the experimental ones. The equations are of the form: potential as a function of the logarithm of the current plus logarithms of other factors such as the equilibrium constant for the reaction. Occasionally, a least squares curve fitting routine will be needed. The data will be used to determine the nature of the species in solution and the kinetic parameters of the processes occurring at the electrode surface. (Denis F. Decraene)

2702-77013 Educational Psychology. Views of Elementary Guidance. Four hundred and sixty-three elementary school teachers in 23 schools were asked their views about 18 functions performed by elementary school counselors. By means of a questionnaire the teachers were asked (1) Was the function performed in their building; (2) How well was it done; (3) How important is the function. The responses are to be analyzed in respect to personal characteristics of teachers and use of the counselor in school building. The data will be analyzed by means of chi square. (Henry Kaczkowski)

2703-77015 T Economics. Quality as a Factor in Automobile Demand. The research problem is to quantify quality changes in automobiles, 1949-65. The method utilized rests upon extraction of a quality index from used car prices. This quality variable is tested by inclusion in a regression model for automobile demand. Coefficients for the multi-equation regression model are estimated by limited information, single stage least squares, and two-stage least squares methods. Data were obtained from various industry and financial publications. (Dennis Boland)

2704-77016 T Psychology. Genetic Analysis of Water Regulation in the Rat. Several parameters of water regulation in the Holtzman strain of albino rat were measured. Data were obtained under normal feeding and drinking conditions and under deprivation conditions. The measures taken include water intake, urine output, food intake, body weight, and urine chloride and total solid concentrations. The main part of this project involves selectively breeding for high and low rates of water turnover. The planned analyses include intercorrelations of the six variables and analysis of variance and hereditability estimates to evaluate the effectiveness of the selection procedures. (R. C. Hostetter)

2705-77017 Psychology. Stochastic Model Simulation. The problem concerns analyzing data simulated from mathematical learning models with factor analysis techniques. The first phase will consist of writing a program to simulate trial ordered response sequences from the pattern model for probability learning. This model is one of the stimulus sampling mathematical learning models that has demonstrated its ability to account for actual

subjects' data in probability learning experiments. In such experiments, the subject attempts to predict which of several outcomes will occur on each of a series of discrete trials. The outcomes which do occur represent an independent sample from a multinomial probability rule.

The second phase will consist of submitting the stochastic simulation runs to a program designed to factor analyze individual learning curves and extract referent learning curves. These programs have been developed by Dr. Ledyard Tucker of the Psychology Department at Illinois.

The aim of the research will be to bridge the gap between the mathematical models approach in analyzing learning data and the factor analysis approach. The former models generally entail the assumption that all subjects in a group have the same parameter values in a stochastic process designed to account for group statistics obtained from learning experiments. The latter approach, while remaining theoretically neutral, attempts to describe each subject in a group by his loadings on certain referent learning curves which are extracted by a factor analysis of the individual learning curves.

The expectation is that, despite the apparent assumption of no individual differences in the mathematical models, the factor analysis will, nevertheless, reveal several referent learning curves. If such a result were to be obtained, it would suggest that mathematical learning models, despite the assumption that all subjects in a group have identical parameters, are capable of predicting considerable individual performance variability in a learning experiment. (William Batchelder)

2706-77018 Civil Engineering. A Statistical Study of the Strength of Steel Columns. The strength of a steel column is materially affected by the presence of residual stresses due to cooling, initial curvature of the member, and eccentricities in the application of loads. Since these factors are ramdom in nature, it is desirable to obtain a probabilistic measure of their effect on strength. It is intended that the computer be used to formulate this statistical model of column behavior. (B. R. Ellingwood)

2707-77019 Theoretical and Applied Mechanics. Fracture Toughness of Metals. Crack growth rates in a wedge shaped, double cantilever beam specimen are to be determined as a function of both crack extension force and stress intensity factor. When a constant load is applied to the specimen either constant or linearly increasing crack growth rates result. This phenomonen is mainly due to the specimen's geometry. The crack extension force and stress intensity factors are related to load by the derivative of the experimentally determined compliance. Algebraic computations, derivatives, and least square curve fitting techniques will be used to solve the above problem. (W. A. Van der Sluys)

2708-77020 Physics. Phenomenology of High Energy Scattering Amplitudes. Amplitudes computed from models for strong interactions (e.g., Regge model and absorption model) will be compared with available data. In some cases, where cross section moments are reported, this will involve inversion of simple systems of equations to obtain helicity amplitudes in terms of these moments. In other cases, where only differential cross section data are available, least squares analysis will be necessary to constrain adjustable parameters in the amplitudes. The computer results will be used to study the validity of the models used to compute the amplitude and to investigate possible modifications of these models. (P. B. James)

2709-77021 T Psychology. Cognitive Appraisal of Threat and Personality. This research investigates the relationships of two personality dimensions--the Authoritarian personality dimension and the repression-sensitization dimension--and the method in which a threatening situation is viewed. Ninety female subjects were administered instruments designed to measure these personality dimensions. They were then given an attitude survey to determine their preferences for natural childbirth. A film entitled, "A Normal Birth," and sponsored by the American Medical Association was then shown to the subjects. Changes in attitude, and the emotional experiences the subject perceived herself as undergoing during the film, are analyzed in terms of the aforementioned personality dimensions. The analysis will utilize linear and partial correlation procedures and the balanced analysis of variance option of SSUPAC. (Ray Levine)

2710-77022 Education. Test Data for Prairie View Project Curriculum Development for Freshman English. This research is designed to evaluate the effectiveness of an experimental project in Language Arts. The total experimental sample numbered 750 freshman students at Prairie View A & M College. A random sample of 75 freshman boys and 75 freshman girls was drawn from the total population for use in the evaluation and analysis. The data are to be analyzed by T-tests comparison between the sexes of students in the experimental sample. A criterion groups of high ability freshmen who were not project students will be used in a comparison of their skills deficits with those deficits within the random sample of 150 project students. These comparisons will be made by item analyses of the Diagnostic Reading Test, the Brown-Carlsen Listening Test, and the Missouri College English Test. (Hubert Smith)

2711-77023 T City Planning. The Impact of Buildings and Land Use Upon Motor Vehicle Accident Causation. The problem is to examine the impact of physical forms (buildings, street furniture, etc.) generated by the land use activity surrounding urban roads as elements of motor vehicle accident causation. It is hypothesized that the physical forms surrounding urban roadways distract the driver from his primary task of vehicular operation. Such distraction may be due to the efforts of the driver, consciously or subconsciously, to perceive the surrounding forms while moving down the roadway. Several physical and psychological variables, in terms of driver distraction hypotheses, will be tested in built-up areas surrounding arterial streets in the city of Chicago. The areas that will be chosen will exhibit a normal distribution of low to high mid-block - head-on, rear-end or fixed object - accident rates involving only drivers from out of the Chicago metropolitan area. The variables to be tested, as building setbeck, the width of the driver's visual field and the textural and proportional relationships between adjacent buildings, will be compared through a multiple correlation procedure in an attempt to determine if and how a physical form - accident correlation exists. Preliminary to any correlation procedures will be the selection of a stratified sample of locations yielding a normal distribution of accidents. In selecting the sample, all physical and traffic flow elements of the locations will be held constant. The only elements which will be allowed to vary will be the independent variable,

physical forms, and its dependent variable, accidents. The expected correlation should yield the variables directly related to driver distraction. From a study of these variables quantitative design limits as well as qualitative design principles will be enumerated in an effort to stipulate some guidelines for the design of forms surrounding urban roads directly related to the perceptive needs of the motor vehicle user. (Leslie S. Pollock)

2712-77024 Civil Engineering. COGO Implementation for Translator Generator. COGO is a procedure-oriented language that has proven useful for solving problems in plane geometry, particularly in the area of land surveying. The present research effort will expand the capabilities of COGO in several ways, including addition of facilities for handling three-dimensional geometry. Expanded COGO will be useful for generating the point coordinates required as input to STRESS. The COGO compiler is a collection of subroutines under control of a monitor program. In the expanded system, the monitor will be provided by an augmentation of the Translator-Generator, a program developed by the Department of Civil Engineering for compiling tabularly specified procedure-oriented languages, and for providing an organizational framework for application subroutines, or interludes. The IBM 7094 will be used to develop and "debug" expanded COGO subroutines written in FORTRAN. These subroutines will be incorporated as interludes of the augmented Translator-Generator. (F. Hatfield)

2713-77025 Agricultural Economics. Rural Development Research Project. Agricultural economists at the University of Illinois are concentrating on a study involving (1) an analysis of factors influencing the effectiveness of university contracts for conveying technical assistance and (2) the effects on U. S. institutions of participating in international rural development assistance. Data have been collected through questionnaires sent to U. S. university staff members who have returned from overseas contract assignments, their wives, their department heads, and their colleagues. Further data were obtained through personal interviews on U. S. university campuses. Data processing will involve primarily frequency counts and cross tabulations. A few correlations of selected variables are planned. Data processed by the computer will be used to prepare reports for ten sub-projects as follows:

(a) campus backstopping organization and practices; (b) contract team characteristics; (c) the role of executive visits; (d) participant training effectiveness and impacts; (e) capital and commodity assistance; (f) project evaluation policies and practices; (g) contract-AID-host country relationships; (h) effects on U. S. universities - departmental impacts; (i) effects on U. S. universities - policies and international programs; (j) the role of universities in international rural development. (Harold D. Guither)

2714-77026 T Civil Engineering. The Simulation of Concrete Response With a Discrete Element Model. A discrete element model is used to simulate the response of concrete to multi-axial loading. The model consists of tension and compression struts joined at the node points by non-deforming spheres of negligible diameter. The stress-strain curves for the struts are linear; however, the strut areas are expressed as a function of strain. The equations derived for the strut forces are, therefore, non-linear.

An iterative method of solution has been developed and will be employed to determine the strut forces and, in turn, the response of the model to a given loading condition. This method involves the assumption of certain member strains, the calculation of all other strains from compatibility requirements, and the satisfying of equilibrium equations.

The primary purpose of the model is to permit the prediction of the response to axial load of a concrete column reinforced laterally with closely-spaced rectangular ties. In the calculations the ties are represented by forces at the four corners of the model. (E. G. Burdette)

2715-77027 Civil Engineering. Analytic Aerial Triangulation for Highway Location and Design. This project involves the formation and adjustment of photographic strips and blocks of strips. The method of least squares is used to simultaneously solve for all the parameters of the photogrammetric system. In a few cases, polynomials are fitted to available ground control. (H. M. Karara)

2716-77029 T Botany. Absorption Spectra of Photosynthetic Organisms at Low Temperatures. Absorption and fluorescence spectra of photosynthetic organisms have been measured at low temperatures. In order to obtain an accurate absorption spectrum, scattering and emission light of the cells should be taken into consideration. Data points were obtained by shining monochromatic light guided through a fiber glass light pipe to the samples. The transmitted light is guided through a second monochromater, amplified by a photomultiplier, and then recorded. The computer is needed to calculate the fluorescence integral by means of Simpson's Rule. The computer is also needed to perform the corrections for the photomultiplier response curve. (Govindjee)

2717-77031 Political Science. School Political Socialization Study. A twenty-page questionnaire, designed to measure the degree to which school-age youngsters are aware of the norms governing the interaction of citizen and police in the United States and to which they would respond appropriately in a hypothetical situation, was administered to 284 children, ranging from grade 2 through grade 12, in the Champaign Unit 4 School District. Students were also scored on a number of postulated independent variables, including affect toward the law, affect toward the police, legal information, sex, social class, intelligence, authoritarianism, interpersonal trust, and parental-permissiveness. The inquiry is directed toward assessing the relative contribution of the independent variables to the socialization process in this specific (citizen-police) role area. Developmental patterns of certain variables will also be charted by age.

DCL facilities are requested for keypunching, combining items into scales, item analysis, product-moment correlations, and a regression analysis to test a series of hypotheses about the direction and relative strength of causal factors in the socialization process. The results will be used to attempt to validate a "social learning" model of political socialization. The interpretation of the results will be made available, in report form, to Unit 4 schools and submitted for possible publication. (Fred S. Coombs)

2718-77032 T Education. Self-Exploration in Counseling as a Function of Conditioned Positive and Negative Self-References. The 80 subjects for this study were recruited in part from volunteers among students requesting conferences at the Student Counseling Service and in part as paid volunteers from several university classes. Subjects were divided into four groups: two experimental and two control. Data consist of taped interviews of the subjects with the experimenter and with four participating staff members from the Student Counseling Service. Four paid graduate student raters rated these taped interviews for number of positive and negative self-references and for self-exploratory behavior as defined by the Truax scale of depth of intra-personal exploration. Differences in self-exploratory behavior in the final of three sessions are expected as a function of differential conditioning of positive and negative self-references in the first two sessions for the experimental groups. Means, variances, and correlation coefficients will be computed on both variables for the various pairs among the raters in order to determine reliability of the ratings. A one-way analysis of covariance will then be performed in order to study differences among group means in the final session while equating the groups for operant level of emission of self-reference statements and self-exploratory behavior. Analyses of variance will be made in order to study levels of emission of self-references and self-exploratory behavior at various points during the three sessions and thus determine whether or not conditioning of self-references has taken place and what effects such conditioning has had upon the emission of self-exploratory behavior. Finally, multiple comparisons will be made among various means in order to test more specific hypotheses. (Kennalee LaFrance)

2719-77033 Agricultural Economics. Selected Characteristics of Rural Public Aid Clients in Illinois. This study will center around two basic questions: (1) what are the chracteristics of rural public aid clients in Illinois; and (2) is there any association between degree of urbanization of counties and the characteristics of clients, the precipitating situation, and the amount of aid provided to the clients by the county Department of Public Aid? The major data source will be the State Department of Public Aid which has information on each public aid case stored on tape. A systematic stratified random sample of one month's data based upon the degree of urbanization of the counties will be used in this study. Analysis will consist of

frequency distributions and measures of correlation of the pertinent variables. The final report will be organized around the two basic questions previously stated. This study is intended to open further lines of inquiry in this area. (D. E. Lindstrom)

2720-77034 Mechanical Engineering. Rocket Nozzle Reaction. Previously developed programs for the calculation of the pressure and temperature fields within a rocket nozzle, which employ the methods of characteristics and wave cancellation, will be extended to include the effects of non constant specific heats and the effect of chemical reaction upon the specific heats. The chemical reaction calculations will be performed by subroutines which use the Brinkley techniques and are available as library subroutines at this facility. (L. D. Savage)

2721-77035 Psychology. Statistical Analysis of Human Variation. Although it is a widely recognized fact that there is considerable biological variation within and among human beings, this area of human biology has received very little systematic attention. About 10 years ago the responsible investigator completed five years of research on survival rations for the Air Force. Over 200 healthy young men participated as volunteers. During the course of the field investigations, some 85 different biochemical and physiological measurements were made at weekly intervals for six weeks in two separate field studies. Because of the nature of the experimental design of these studies, the mass of data that was accumulated was admirably suited for initiating a systematic examination of human variation. The responsible investigator has published several articles based on these data in Biotypologie (a journal devoted to human biometry) and in the Annuals of New York Academy of Sciences. From these studies certain questions have emerged which can be answered by further detailed statistical studies.

What is the correlation among various biological traits? This question stems from a consideration of the mathematical independence of morphological, biochemical, physiological, and behavioral measurements (traits) that might be used to characterize an individual. One wonders how independent these traits actually are. A search of the literautre suggests that the correlations between traits are generally low. Coefficients of determination

range from 25-50%. The low coefficients raise some intriguing theoretical questions about the homeostatic processes in the body. One hypothesis advanced by E. Schreider suggests that the organism may actually consist of a complex of subsystems. Traits within subsystems are highly correlated. When traits from different subsystems are related, the correlations are low. This hypothesis leads to a second question. Do biologically meaningful clusters of traits emerge when measurements of human beings are studied by component analysis? A third question focuses on men under stress. What effect does nutritional stress have on trait correlations? Some observations from the literature suggest that the integrity of subsystems breaks down during illness. The young men of the survival studies were abruptly transferred from adequate diets and comfortable quarters to simulated survival conditions which did in fact provoke clinical and laboratory evidence of dysfunction and deterioration. These data can thus be used to explore how trait correlations change when young men experience acute stress.

Other topics that will be studied include patterns of individuality and inter-individual variation of intra-individual variation. (F. Sargent)

2722-77036 Computer Science. ILLIAC III Simulator. An ILLIAC III simulator will be written which will permit debugging and running of ILLIAC III programs by simulation until the ILLIAC III hardware is completed. Initially, one of each of the ILLIAC III units will be simulated: a Taxicrinic Processor, an Input/Output Processor, an Arithmetic Unit, an Interrupt Unit and a Pattern Articulation Unit. Then multiple units will be simulated so that the actual configuration of the ILLIAC III will be duplicated by the simulator. Finally, the Scanners and Monitors of the ILLIAC III will be connected to and run by the 360/50. Thus, while the ILLIAC III hardware is being completed, complete ILLIAC III programs can be written, debugged, and run using the 360/50 simulator and the actual ILLIAC III Scanners and Monitors. (McCormick)

2723-77037 T Chemistry and Chemical Engineering. Turbulence in the Immediate Vicinity of a Wall. The object is to calculate some one-dimensional definite integrals. These integrals arise in the calculations of spectra, intensity, and average values of mass transfer coefficient for turbulent mass transfer close to the wall. Mechanical quadrature is being proposed for use. (Kamalesh Sirkar)

2724-77038 T Chemistry and Chemical Engineering. Crystal and Molecular Structures of Boron Hydrides. This problem involved the determining of crystal and molecular structures of several Boron Hydride compounds by single crystal x-ray diffraction techniques. The computation required will include the scaling and checking of intensities, Fronrier synthesis, Patterson synthesis, direct method phase determinations, and least squares refinement of the structures. (L. J. Todd)

2725-77041 T Nuclear Engineering. Heat Transfer in Gas-Solid Suspension Flow. An experimental and theoretical investigation demonstrating the feasibility of improving heat transfer in gas-solid suspension flow in which the solid particles are electrically charged and are acted upon by forces due to a fluctuating electric field. An analytical model based upon the fundamental conservation equations is being studied. Numerical methods will be tried in solving the resulting non-linear differential equations, and the solutions will be compared with the experimental results. (Ali El-Saiedi)

2726-77042 General Engineering. Strip Mining Plan. The computer is being used to generate strip mining plans from bore hole data and mine machinery parameters supplied by an Illinois Coal Mining Company. The computer will generate topographic maps of the property and alternate mining plans. An iterative process for selecting the optimum plan or plans is being considered. A strip mine plan consists of a schedule of the areas to be mined each year, including the length and cross section of the pits, an estimate of the total cubic yards of overburden to be moved, and the yield of coal. The criteria for selecting the plan are production requirements, workload balance, provisions for permanent structures and land reclamation. (D. E. Scheck)

2727-77043 Education. Need Orientation and Perception of Ideal Supervisory Style. Leadership research reveals two critical dimensions of leadership behavior, focusing on people (human relations, consideration, employee centered) and focusing on the job (task oriented, production centered, initiating structure). Further, the literature is explicit in suggesting that the two dimensions are mutually exclusive. Moreover, appropriate leadership behavior is generally regarded as containing both the task and people dimensions. The exact mix of this proportion, however, remains unknown. A more realistic approach to appropriateness of style is to adopt an "it depends" posture. Samples of it depends variables are task structure, leader-member relations, group sentiment and need orientation of subordinates. This project is concerned with need orientations of teachers and the effect that this variable has on teacher perceptions of ideal supervisory behavior. Need orientations are operationally defined as an individual's score on a choice-motivator scale. The scale is designed to fix each respondent on an approach-avoidance, motivator-hygiene, intrinsic-extrinsic continuum. Perceptions of ideal supervisory behavior were measured by the Leadership Behavior Description Questionnaire-12. The sample consisted of 264 teachers enrolled in eight sections of Educational Psychology 311 at the University of Illinois 1967 summer session. The statistical analysis will consist of reliability checks, LBDQ item factor analysis, LBDQ sub-scale factor analysis and appropriate correlation techniques. Results of study will be submitted for publication in professional journals. (T. Sergiovanni)

2728-77044 Political Science. Voting Behavior of the American Negro. The study seeks to compare and contrast the voting behavior of the American Negro over the past decade with the political behavior of the native, white American and the immigrant American naturalized citizen. The primary focus of the study is on what political scientists call the long term component of the political response. This consists of patterns of behavior into which the individual tends to be socialized and which remain relatively immutable by the ephemeral events of particular campaigns. The computer will be used primarily to calculate standard statistical routines, i.e., cross tabulation, correlation, regression, factor analysis and procedures generally available in most packages, but which must be special purpose programmed for this data owing to weighting factors and alpha-numeric coding. In addition to the statistical routines

mentioned above, the computer will be used to reformat and recode much of the data which comes from four different data sets and which unfortunately have similar but not always comparable coding schemes. The data for these projects were collected by the University of Michigan's Survey Research Center during their presidential election studies. The data have been made available through the Inter-University Consortium for Political Research and through the offices of the Survey Research Laboratory's Data Repository. (A. H. Miller)

2729-77045 Civil Engineering. Dynamic Analysis of Inflatable Shells. The vibrations of inflatable shells are to be studied using a superposition theory: small oscillations about the static non-linear solution for the pressurized shell will be considered. Since these small oscillations interact with the force resultants of the pressurized shell, the field equations are not linear in the usual sense of the word. The numerical solution to this combined boundary-value and initial-value problem will be sought using a modal analysis. The results of the modal analysis will be used in the study of the forced vibration behavior of inflatable shells. Various numerical integration schemes will be tried, e.g., Newmark's beta-method, asymptotic integration, and their relative merits investigated. The chosen solution methods will be tested on several sample problems with various contours and boundary conditions. (J. W. Leonard)

2730-77046 T Agricultural Engineering. Hydrologic Characterization of Small Watersheds. The hydrologic response of watersheds to storm rainfall is to be studied through the use of a mathematical model which simulates the surface runoff process. The model is based on the partial differential equations for unsteady spatially varied flow. The computer will be used to solve these equations by an implicit integrating procedure. The solutions will describe the spatial and temporal distribution of flow and storage over specified prototype watersheds. The characteristics of the outflow hydrographs will be related to rainfall duration and intensity, and stream channel density (number of miles of channel per unit of watershed area). Channel densities, frequencies, and slopes, and watershed areas will correspond approximately to values determined through topographic stuides of actual watersheds in Illinois. (Rastogi Ramavtar)

2731-77047 Food Science. Production of M/e vs. Intensity Tables and Graphical Display of Mass Spectral Data. The Food Science Department has available a Hitachi RMU 6E single focusing mass spectrometer with an attached digital data acquisition system for recording the data. The services of this system will be available to all staff and students of the College of Agriculture carrying out research. The data acquisition system will be especially valuable for recording data from gas chromatographic systems employed with the mass spectrometer. The output of the mass spectrometer is digitized at a rate of 3000 data points per second and written on magnetic tape while the instrument scans from mass 20-500 in 1-3 seconds. The computer reads the tape, finds the peak centers, assigns them mass values and intensities, and prints the resulting spectrum in numerical form and plots it graphically. Other manipulations of the data can also be carried out. The initial program is that developed by Dr. K. Biemann of M.I.T. and will be available for our use and modification (FORTRAN II, written for 7094, M.I.T. Computation Center). (Edward G. Perkins)

2732-77048 State Water Survey. Flagstaff Drop Size Spectra. A raindrop camera is being operated in Flagstaff, Arizona. The film from this camera has images of the raindrops. These images are measured and the measurements transferred to IBM cards. The cards will be processed by the computer to obtain drop size spectra, the rainfall rate, the radar reflectivity, and liquid water content. These variables will then be computer processed to determine the empirical relationships between rainfall rate and radar reflectivity under the low humidity conditions prevalent in Arizona. (D. M. A. Jones)

2733-77049 T Electrical Engineering. Minimization by Decomposition. A minimization algorithm will be developed to minimize an n variable network using a given set of elements with restricted inputs. The minimization technique to be used is that of decomposition. Partitions of the variables will be considered and functions which can be realized by these partitions will be looked at to get a minimal circuit. The main algorithm will be to assign values to the "don't care" points in the partition matrix and the processing of this partition. (John Boese)

2734-77050 Civil Engineering. Shear Wall Truss Analogy. The analysis and design of shear walls is of great importance in structural engineering. The existing methods of analysis are either too simple and over-conservative approximations or are too involved for practical use. The objective of this research is to develop a practical method for the analysis of buildings with shear walls by finding trusses that are equivalent in their overall behavior to the shear wall panels. These trusses can be analyzed by using STRESS or special stiffness method programs. The results thus obtained would be compared with those obtained by more precise but more time consuming techniques like finite element method. (S. G. Haider)

2735-77051 T Physiology. Effects of Temperature on Cation Fluxes in Erythrocytes. The radioisotopes, Na^{24} and K^{42}, are being used to characterize the fluxes of these two cations in erythrocytes of selected species of rodents. Major emphasis is on the effects of low temperatures (5-15° C) on the active and passive components of these fluxes. The computer will be used to correct the measured radioactivity for decay of the isotope and machine dead time. Absolute and relative volumes of the cells during the experimental period, specific activity of the cells and medium, and the magnitude of reverse fluxes from the cells will be calculated using standard equations and the computer. Statistical analysis of the data will also be performed with the computer. (S. Kimzey)

2736-77053 Engineering College and Station. Graphic Language Development. The basic goal of this project is to develop a user oriented Graphical Display Language. The method used to develop the language will be to review the requirements for Graphical Display Systems and develop the language elements to define the basic graphical shapes to be displayed. The prime application areas for the language will be man-machine interface in which the language provides the means of translating the users request into machine understandable form. (A. B. Carroll)

2737-77054 State Water Survey. Hydrometeorological Studies of Precipitation. Various analyses of precipitation data will be made in conjunction with hydrometeorological research pertaining to hydrology and weather modification. This will involve frequency analyses, regression analyses, and numerous types of statistical testing on data grouped by storm, month, season, and year, and relating precipitation characteristics to various meteorological parameters. (Robert Sinclair)

2738-77055 Industrial Administration. Computational Experience with Balas' Algorithm. Integer linear programming, i.e., the maximization (or minimization) of a linear objective function subject to linear constraints and integer restrictions, has proven infeasible from a computational viewpoint. Although several algorithms have been developed to date, none have proven computationally efficient. Depending to some extent on particular problem structure, problems with as few as ten variables and five restrictions have generally taken up to 30 minutes of IBM 7094 time for completion. This is clearly an excessive time given that in practice problems of much larger size need solutions. A recent revision of one of these algorithms, the Balas Algorithm, offers the possibility of reasonable computation time for problems with up to 50 variables and 100 restrictions. The purpose of this research project is to gain some computational experience with the revised algorithm on both both the IBM 7094 and 360-50 using several test problems of varying complexity. If possible, efforts will be made to develop further modifications to the algorithm in view of computational experience. (Laughhunn)

2739-77057 Economics. Estimation of Tax Revenues. The purpose of this project is to develop a model for estimating revenues that will be generated by state income taxes having various forms of tax base, exemptions, and permissible deductions. The model will generate a distribution of state income earners by adjusted gross income and number of exemptions from data provided by the United States Internal Revenue Service. From this distribution estimates of tax revenues can be determined for various size of exemptions, allowable deductions, and tax rates. The results can be used by any state having or contemplating state income taxes for purposes of planning public expenditures and allocating the burden of the income tax to various income groups. Accurate revenue estimates facilitate better state budgeting. (A. J. Heins)

2740-77059 Electrical Engineering. Satellite Ephemeris. This research is concerned with the reduction of Faraday rotation data to integrated electron content in the ionosphere from an orbiting satellite to the ground. The program calculates the position of the satellite and the value of the magnetic field at that point, and then using the rest of the input data calculates the electron content. (K. C. Yeh)

2741-77060 Chemistry and Chemical Engineering. Chemistry Student Records. We are experimenting with the possibility of keeping student records on card files. This work will eventually be handled by the Statistical Service Unit when we have determined exactly what we want done. The Department of Chemistry and Chemical Engineering has about 400 students who are graduates and over 2000 alumni. We are working toward a complete alumni record containing more data than presently utilized by the alumni association in a form easily kept up to date. This requires both card pack and tape. Printouts in several formats will be wanted from the original input. A running record of graduate students is also desired which will be started upon receipt of the application, will record each decision to admission, and handle all matters, even alumni records, relating to the student. In both of these records the available information in the Statistical Service Unit records will be used. We want our own format where our needs differ from present practice. An attempt will be made to be as compatible as possible with the present system in Stat Service. (Lowstuter)

2742-77061 T Education. Prerequisite Skills in Early Reading. The purpose of the present research is to determine the effects of age and social class on the discrimination of two-dimensional graphic forms in young children. More specifically, an attempt was made to determine whether: (1) socio-economic differences affect the letter discrimination abilities of prereading children; (2) age by social class interactions exist in letter discrimination learning; and (3) the ability to discriminate between certain transformational changes of graphic symbols is a stimulus-specific or stimulus-generalized phenomenon. The data were drawn from 80 children in the Champaign-Urbana area. The analysis consists of a 2 by 2 by 3 by 3 factorial design employing respectively: chronological age, social class, confusability, stimuli, and task levels. There are repeated measures on the last three factors. The SSUPAC version of BALANOVA 5 will be employed. (Henry G. Timko)

2743-78001 Children's Research Center. Special Class Project. This study is concerned with children in three special classes for emotionally disturbed children. Quantitative data of a behavioral, scholastic and clinical nature is collected daily on individual children both emotionally disturbed and normal. This is reduced through automated data processing to 10 day means which are used to assess the progress of the program as a whole and of individual children. After certain longer periods, correlational analyses, T-score transformations and other common statistical techniques are performed to study the reliability of measures, the effect of specific therapeutic manoeuvres and differences between emotionally disturbed and normal children. The CalComp plotter is used to draw yearly graphs of data. (H. C. Quay)

2744-78002 Materials Research Laboratory. Computer Model of Field Ion Microscope Image. A model of a field ion emitter is constructed via a mathematical formulation. A sphere is made to intersect layers of (100) planes in a body centered crystal structure. The radii of the circles of intersection are computed, and distances of all atoms within a certain defined spherical shell computed and plotted to give a simulated field ion micrograph. The model is to be used to evaluate consistency of geometrical configurations of defects obtained on crystal surfaces with configurations obtained by varying the theoretical parameters of these configurations in the computer model. (Guy Ayrault)

2745-78003 T Education. PAD (Privileged, Average, Disadvantaged) Discrimination. The literature on culturally disadvantaged children has references to various parameters which can purportedly be used to distinguish between the learning styles of these children and other children. The purpose of this study is to examine parameters which refer to mode of reasoning (inductive, deductive), perceptual organization (external, introspective), and temporal perspective. Multiple discriminant function analysis will be used on data from a battery of 11 subtests relevant to the parameters. The subjects are 550 seventh graders from schools in Memphis, Tennessee, and New York City. The students are classified as disadvantaged, average, or privileged on the basis of results on a questionnaire administered to each. The output will consist of the usual descriptive statistics, a pair of linear functions, and significance tests. The weights assigned to each variable in each discriminant function will provide an indication of the usefulness of the parameters in distinguishing among the groups. (O. R. Brown, Jr.)

2746-78004 Psychology. Circadian Rhythms of Adrenalectomized Rats. This experiment is based on a 2 x 2 factorial design investigating various aspects of behavior and physiological variables. The independent variables are physiological condition (adrenalectomized vs. sham operated normal) and lighting condition (maintained in constant light vs. in a 12:12 hr. light cycle), and five rats served in each of the four groups. Rats were housed in activity-metabolism cages with powdered food, tap water, and 1.5% NaCl in tap water available ad libitum. Rats were weighed, cages cleaned, and food and water replenished on a random schedule. After 14 days of adaptation to these conditions, measures of nine variables were made every hour for 351 consecutive hours. The variables measured were activity wheel revolutions, food intake, water intake, saline intake, urine volume, urine refractive index, urine Cl^- concentration, urine Na^+ concentration, and urine K^+ concentration.

The major question to be asked of the data is whether or not adrenalectomized rats housed in constant light show less synchonization among the variables measured than do rats maintained under the other three conditions. A new model for analysis of variance will be used which does not require the assumption of homogeneity of variance among groups.

If the four groups differ significantly in the analysis of variance, with adrenalectomized rats "less synchronized" than normal rats, an attempt will be made to describe the nature of the desynchronization. The rhythmicity of each of the nine variables will be investigated for each S by organizing the data into matrices with the number of columns equal to the trial period length (18 to 30 hours, since circadian rhythms are of primary interest), computing row and column means, and computing F = variance among columns/variance among rows. If a true period is present, F should increase as the number of columns approachs the number of hours representing true period frequency, and the best estimate of period length would be that number of columns which maximizes F. This information should allow a decision to be made as to whether the desynchronization of adrenalectomized rats is due to differences in period frequency between variables or simply to more random fluctuations superimposed on cycles with the same frequencies as those characterizing normal rats. (L. I. O'Kelly)

2747-78005 T Agricultural Economics. The Economy of Beef-Cow Herds in Illinois. The objectives of this research are: (1) to estimate farm production rates and resource requirements for beef cow herds with feeder calves sold under alternative resource situations; (2) to develop hypotheses that explain the presence of beef cows on Illinois farms; and (3) to predict the conditions under which alternative beef cow herd systems may be profitable as a part of the farm organization in alternative areas of Illinois.

The availability of resources for beef cow herds in Illinois counties will be gathered from the 1964 Census of Agriculture. Basic data on farm production rates and resource requirements under present practices and alternative resource situations will be gathered from a sample of farms enrolled in the Farm Bureau Farm Management Service. By linear programming analysis of the available resources and input-output relationships of beef cows, the potential beef cow expansion in Illinois and the income generating power of beef cows will be determined. (R. K. McClelland)

2748-78006 Theoretical and Applied Mechanics. Fatigue of Hard Steels. The main problem is the study of the fracture properties of hard steels. The computer will be used to obtain a least squares fit of fatigue data such as a fatigue life vs. strain level or stress level plot. Also a numerical calculation of the area under a hysteresis loop is necessary. Finally the computer will be used to calculate different values of temperature compensating factors for the steels used. (Ron Landgraf)

2749-78007 Civil Engineering. Mechanics of Surface Runoff from Watersheds. The explicit scheme of the finite-difference method for the specified time intervals will be used to solve a set of quasilinear partial differential equations, which are formulated based on the laws of conservation of mass and momentum. Any prescribed initial conditons with the help of the prescribed boundary conditions on the ridge of watershed and at the junctions of overland flows and channel flows will be input to obtain the flow depth and velocity at any time at any grid point in a watershed due to a pattern of moving storm. (Ven Te Chow)

2750-78012 Physics. Spark Chamber and Counter Experimental Analysis. Data pertaining to the fundamental nature of the so-called "elementary particles" were obtained using spark chamber and counter equipment. The standard techniques of geometrical and physical reconstruction of the recorded events are to be used via computer. Additional computer use is required to check the feasibility of future experiments with the same equipment. This will require the use of Monte Carlo and other techniques to simulate actual physical events. (William Bertram)

2751-78014 T Psychology. Delay of Reinforcement and Post-Feedback Interval. This study represents an investigation of the effects of a delay before feedback and a delay after feedback on the acquisition and recall of material of varying difficulty. Other research has indicated the importance of these time intervals. Second and third graders were given a series of two-choice discrimination problems and tested for recall one week later. At both testing times automated equipment delivered "feedback" consisting of: a) a red light below correct choice; b) a click if response was correct, a buzz if response was incorrect; and c) a bead, exchangeable for toys, if response was correct. The conditions represented combinations of values of the following factors: delay of feedback interval, post-feedback interval, and task difficulty. Dependent variables included the number of correct responses, latency of each response, and gross physical activity of the subject during testing. The study can be logically separated into two experimental designs: a between subjects design, and a mixed between and within subjects design. Projected mathematical analysis includes two analyses of variance for each design: a) one for data existing in the form of single scores for subjects and b) one for trial by trial data in which trial number may be included as a factor. The results may be expected to have some implications for instructional techniques, especially programmed instruction. (Susan Wooley)

2752-78015 T Theoretical and Applied Mechanics. Shelling of Crane Wheels. Computer facilities will be used to fit curves to data obtained from our testing machines. Additional calculations will be made to determine the contact stresses for various loading conditions that are encountered both in industry and in our lab.

The research program currently being conducted is the laboratory testing of crane wheel models in an attempt to evaluate the pitting resistance of various types of steels that are in use at the present time or under consideration for possible use in the future. These models are subjected to various loading conditions in an effort to accelerate the time needed for failure to occur. It is necessary to calculate the stresses in the models in the vicinity of contact and compare them with the stresses found in the full sized wheel. As stated above, the computer will be used to obtain the best fit for the experimental data. The contact stress equations are rather lengthy and quite difficult to work with. Consequently by using numerical techniques, it will be possible to obtain the normal, tangential, and shear stresses thus giving information on how stresses vary both radially and circumferentially near the point of contact. (Gary Homan)

2753-78016 T Political Science. Analysis of Indian Political Attitudes. This investigation will examine the relationship between certain political attitudes and party identification in the Indian political system. The analysis will rely upon basic statistical tests of significance and measures of association. The data were obtained from the Survey Research Center of the University of California, Berkeley, California, which conducted the national sample survey in India in 1963-1964. The results of this secondary analysis will be one component of a doctoral dissertation concerning political alienation and apathy. (David D. Dabelko)

2754-78017 Education. The Effects of Success/Failure Feedback on Task-Attitude and Task-Persistence. Two separate studies on the effects of success/failure feedback on motivational orientation were conducted.
STUDY I. The specific goals of Study I were to determine whether or not voluntary persistence at a task is a joint function of (1) selected personality variables, and (2) variation in the ratio of success/failure administered during task performance. Subjects received varying ratios of success/failure feedback as they worked at several language deciphering tasks. After completing several items of each task, subject was allowed to stop at any point he wished without penalty. The length he voluntarily persisted at a given task was used as a measure of the dependent variable. Personality measures were obtained

earlier in another setting. Multiple regression is to be used in determining the differential effects of the personality factors in influencing persistence under the varying success/failure conditions. STUDY II involved a determination of the effects of success/failure feedback on stated attitudes in a non-contrived instructional setting. Subjects were students in an undergraduate psychology course. At the beginning of a five-week unit on mental illness and treatment, subjects were asked to assess their own competence in recognizing the symptoms of mental illness. At the end of the unit, subjects estimated the liklihood of receiving various grades on the unit test. After the grades were assigned to the unit, subjects again evaluated their competence in the area of study. Also, a measure of their attitude toward the instruction received was obtained. The specific goals of the study were: (1) to determine the change in subjectively judged competence as the result of a learning experience; (2) to determine how the grade administered would affect both judged competence and attitude toward the class; (3) to determine whether the expectancy of the subjects may be a factor in determining whether the administered grades will affect subjects judged competence and course attitudes; and (4) to determine how certain personality variables may modulate any observed attitudinal changes. Data evaluation will involve a factor analysis of the specially contrived "Judged Competence" scale. Analysis of variance designs will be used in evaluating the data related to goals 1, 2, and 3. Multiple regression and/or discriminant analysis will be employed in connection with goal 4. (Martin L. Maehr)

2755-78018 Marketing. Economics of Advertising. The relationship of advertising to liquor brand sales is being investigated further, with the aid of step-wise multiple regressions. Pooled estimates will now be obtained, whereas estimates for individual brands were developed in prior analyses. (Julian L. Simon)

2756-78019 T Advertising. A Study of Social Character in Relation to Attitudes Toward Advertising and the Mass Media. The research project is a questionnaire survey of 180 college students concerning their attitudes toward specific advertisements, their attitudes toward advertising and the mass media in general, and their preferences for magazines and types of television programming. T-tests and analyses of variance will be used to

determine the extent to which inner-directed and other-directed respondents differentially prefer various advertisements and mass media. The computer results will be used to determine whether there is statistically significant differential preference on the part of the respondents. SSUPAC program will be used in the computing of T-tests, frequency counts, and analyses of variance. (John Hicks)

2757-78023 T Aeronautical and Astronautical Engineering. Rotating Hollow Sphere. A numerical solution for the displacements of a rotating, hollow, thick-walled sphere will be found from the equations of elasticity. The computer will be used to sum several finite series of terms obtained from an algebraic solution to the problem. (Walter Dwyer)

2758-78024 Sociology. Data Analysis for the Rural Industrial Development Project. The Sociology and Agricultural Economics Departments are jointly studying the effects of rapid industrial development on a predominantly rural area. The town of Hennepin, Illinois, (pop. 400) was selected as the site for a new steel plant that will employ about 1,000 persons at the beginning of operation. This project is investigating the effects of this new and large industrial development on the town of Hennepin and the surrounding area. The major research method used in this project is the repeated surveying of a probability sample. This sample consists of 1100 heads of households. These persons will be interviewed five times over a six year period. The first survey was conducted last summer and the second is being conducted this summer. The data from each interview is coded and punched onto 17 IBM cards. The large amount of data obtained from each survey makes analysis possible only through the use of the computer. The mathematical methods used will be the standard statistical techniques used in Sociology for the analysis of data from large surveys. Among the most important methods used will be correlations, analysis of variance, frequency counts and calculations of sampling errors. The results of these calculations will be used to prepare preliminary reports each year which will be circulated among other researchers working in the area of industrial development. These preliminary reports will be used as the basis for a comprehensive final report at the project's conclusion in 1971. (Gene F. Summers)

2759-78025 T Chemistry and Chemical Engineering. Equilibrium Constants and Concentration of Complexes. The concentrations and equilibrium constants of various optically active chemical complexes, X_aY_b (where a represents the moles of metal X and b represents the moles of ligand Y in the complex), are to be calculated. The total rotation in degrees of solutions containing various known concentrations of X and Y is experimentally determined using a polarimeter. A computer program involving iteration processes will be used to solve a set of simultaneous equations which express the total rotation in terms of the equilibrium constants of the complexes present and the equilibrium concentrations of X and Y. The concentration of a complex can then be calculated by substituting the calculated equilibrium constant for that complex and the calculated equilibrium concentrations of X and Y into the equilibrium constant expression for that complex. (Gerald Sipes)

2760-78026 Agricultural Engineering. Livestock Waste Management. Aerobic waste treatment pilot plants will be constructed in the laboratory. The computer will be used to analyze chemical and biological data, taken in the laboratory, by means of regression analysis and comparing computer drawn curves. It is expected that the analysis will provide the optimum prototype design parameters for field constructions. The computer will also be used to determine the efficiency and possibly a cost analysis of the actual system in the field before making a final recommendation to livestock farmers. (Don D. Jones)

2761-78027 T Geography. Economic Development of the Plains States. The objective of this study is to analyze and describe the economic development of this multi-state region. Statistics compiled from the Census of Population since 1870 will be the primary data source; other censuses and sources will provide additional data. The data will be manipulated by the computer to prepare it for further analysis. It is envisioned that various hypotheses tests, correlation analysis and shift-share analysis will be conducted by use of the computer. (Waxmonsky)

2762-78028 T Aeronautical and Astronautical Engineering. Kinetic Theory Approach to Hypersonic Flow Problems. The aerodynamics of a sphere in a highly rarefied gas flowing at hyperthermal speeds, such as a spherical satellite re-entering the earth's atmosphere, is being studied by using the full formulation of kinetics theory of gases (dynamical theory of gases). In this study multidimensional integrals are to be evaluated by a Monte Carlo technique. The results of this study will be to present the flow field and calculate the heat transfer and shear stress to the sphere for Knudsen numbers of the order of one. (Bernard Sindermann)

2763-78029 Political Science. The 1960 Election and the South-Religiosity and Racial Prejudice. This is a secondary analysis of 1960 survey research data from the Survey Research Center at the University of Michigan. The working deck was obtained from the Data Repository of the Survey Research Laboratory on this campus. The Survey Research Center's data come from a nation-wide random sampling technique. The data under analysis for this project, however, are only from the South. A racial prejudice scale has been developed which will be cross tabulated with each respondent's vote or intended vote (for non-voters) in the 1960 presidential election. This basic table will be maintained throughout the analysis while other variables are controlled. The controlled variables include religious preference, strength of religious preference, regularity of church attendance, party identification, and reaction to John Kennedy's Catholicism. A test of relationship (chi square) and a measure of association (gamma) will be calculated for each table. (Thomas R. Kitsos)

2764-78030 Psychology. Subject Pool. Each Psychology 100 student is required to participate in five hours of scheduled experiments as part of the course. These students form a subject pool for the faculty of the Psychology Department. Since there are approximately 2,500 such subjects each semester, the scheduling of each one 5 times generates a considerable inventory problem. Crossfiling of this information on 56 variables per subject is a prohibitive task by hand, but can be readily done by maintaining the file on magnetic tape, transferring it to disk, and performing the necessary crossfiling. Printout will give all information for all subjects available at each of 56 different hours during the week. (Webber)

2765-78031 Physics. Disk Library Maintenance II. At any given time, analysis of data from several bubble chamber experiments is proceeding. A different set of parameters is required by the analysis programs for each experiment. Each experiment has portions which require different constants. The appropriate constants for each experiment and their subsets will be placed on the disk as standard system records. The analysis programs will load the constants as required, enabling events from many experiments to be processed by the same job. (Guy Scharf)

2766-78033 T Political Science. Dimensions of Political Participation. This project investigates the dimensions of political participation. Factor analytic techniques and multiple scalagram analysis available in the SSUPAC package will be employed. The project involves a secondary analysis of data on the 1964 Presidential election gathered by the Survey Research Center of the University of Michigan. The computer results will be used in a proposed Ph.D. dissertation. (Mike Hooper)

2767-78034 T Education. Relationships Between Self-Reported and Observed Test Anxiety. These data were obtained by administering several short inventories designed to measure test anxiety to graduate students in Education and high school freshmen-sophormores taking Algebra. Several days later, additional measures were obtained on these students by observing them as they took their final exams. The computer will be used to compare the data from the self-report responses and the observations. (Donald A. Bender)

2768-79001 Computer Science. ILLIAC IV Translator. The problem is to test proposed computer language translator systems for the University of Illinois designed ILLIAC IV computer. The ultimate goal is a compiler-compiler which, given the specifications of a programming language and a program in this language, will produce a machine language program for execution on the ILLIAC IV. (Robert Northcote)

2769-79011 T Materials Research Laboratory. Resistor Calibration and Thermal Conductivity Calculations. Calibration data on carbon and germanium resistors for use at temperatures from 1° K to 20° K will be fitted to an analytic function involving seven parameters by a computer program developed by R. E. Harris (University of Illinois Physics Department Technical Report). The results of this program will be used in the calculation of thermal conductivity of solid helium crystals grown at the Materials Research Laboratory. Use of the computer will insure accurate analysis of the experimental results. (Samual Clark Fain)

2770-79012 Nuclear Engineering. Ribbed Slab Shielding. This project will study radiation shielding by "ribbed" slabs. Part of the study involves the exact calculation of radiation transport by "Monte Carlo" techniques on the computer. After these results are obtained, approximate, simplified methods will be devised in which the ribs are considered as perturbation on the radiation penetration of a simple slab. These results will be checked against the Monte Carlo results until assured that the simple mathematical model is adequate for the purpose. Then production of data with variation of input parameters will be carried out. (A. B. Chilton)

2771-79013 Mining, Metallurgy, and Petroleum Engineering. Numerical Solution of Laminar Free Surface Flows. Navier-Stokes equations will be solved for two-dimensional incompressible flows with free surfaces. Boundary conditions applied at the free surface are: (1) balance of normal stress; and (2) continuity of tangential stress through free surface. We intend to solve the following problems: (1) splash problem; (2) rising Capillary Flow (contact angle given input); (3) formation of a drop of fluid starting from a square blob (with a given contact angle); and (4) flow of a liquid blob down a sloping plane (with given advancing and receding contact angles). (B. S. Narang)

2772-79015 T Civil Engineering. Applicability of Coarse Grid Sandwich Construction for Beam Webs. An analysis will be made of girder webs which consist of a coarse grid pattern of bars framed and sandwiched between two thin sheets of steel. This is a buckling problem as well as a plane stress problem for the various grid patterns, bar sizes, and plate thicknesses which are selected under given loading conditions. A "finite element" method using

a triangular element, will be used in solving for the stresses within the sandwich. This will involve a large number of equations which can be solved economically only on a computer. Using the stresses found by the "finite element" method, the plates and grid work will be checked to determine if buckling or yielding has occurred; if so, certain variables will be changed in the program and the analysis will be performed again until an "optimum" solution is reached. (James M. Fisher)

2773-79026 Physics. Cyclotron Resonance of Piezoelectric Polarons. The cyclotron resonance frequency of electrons in piezoelectric semiconductors is calculated theoretically with the thermal Green function method. The computer will be used to compute the self-energy of electronic states by numerical integration, and to determine the self-energy by solving a self-consistent equation. (Satoru J. Miyake)

2774-79028 T Agricultural Engineering. Effect of Additives on Diesel Engine Smoke. The problem is to evaluate the effects of diesel fuel additives on the engine smoke intensity, exhaust temperature, horse power, torque, brake specific fuel consumption and fuel air ratio, etc. Data obtained by running different engines at different speeds and loads will be processed with the aid of computer program to compare horse power, brake specific fuel consumption, etc., with and without additives. (Kashmir S. Virk)

2775-79029 Materials Research Laboratory. Design of Superconducting Solenoid. A ten kilogauss superconducting solenoid magnet is to be designed and constructed. The solenoid is to be eight inches long with a one inch inside diameter and must possess an axis field homogeneity of one part in one thousand over half its total length. The maximum allowable current for the wire used is ten amperes at the maximum field strength.

The field calculations will be done separately for each layer of the solenoid using the standard solenoid formula, and the resulting fields added to obtain the total on axis field. The field profile for the uncorrected solenoid will be calculated and plotted. Trimming windings will then be added and the net field profile calculated and plotted until the above homogeneity is obtained. (B. Keith Moore)

2776-79031 T Aeronautical and Astronautical Engineering. Wave Propagation in Vicsoelastic Medium. Stress wave propagation due to an impulsively applied load in a one-dimensional viscoelastic bar is analyzed with the bar subject to a temperature distribution. The governing integro-differential equation is solved by the method of finite differences in the time and space coordinates. At any particular time, expansion of the equation yields N equations in N unknowns in the space coordinates, the coefficients of which depend on the previous time history at those points. These equations are to be solved by matrix methods on the computer. Influence of step size and temperature is to be investigated. (Michael J. Cronk)

2777-79035 Physics. Three Body Scattering. Three body scattering amplitudes are calculated using a new method based on the analytic properties of the scattering matrix as a function of the complex energy variable. The amplitudes are first obtained for unphysical values of the energy by the use of a variational principle. This initial step in the calculation involves the solution of a large number of linear equations. The numerical results thus obtained are analytically continued to the physical energy to yield scattering phase shifts. The calculated scattering amplitudes will be used in the study of atomic and high-energy scattering processes. (L. Schlessinger)

2778-79039 Institute for Research on Exceptional Children. Preschool Program for Disadvantaged Children. This project is designed as a three-year longitudinal study of the remediational effects of a highly structured preschool program on the intellectual, linguistic, perceptual, and vocabulary development of culturally disadvantaged children. The data gathered for analysis was obtained through a pre- and post-test evaluation of the subjects utilizing psychological scales of intellectual functioning, psycholinguistic abilities, perceptual development, vocabulary development, and general school readiness. The facilities of the Department of Computer Science lend themselves to a more efficient analysis of the data because of the cumulative nature of the data, the number of variables, and the number of statistical analyses planned. The initial analysis planned entails the application of t-tests. (Dr. Karnes)

2779-79040 Materials Research Laboratory. Argon Divacancy Concentration. The energy of formation of a di-vacancy in solid argon will be calculated using a pair-wise additive Lennard-Jones 6-12 potential. The near neighbors to the di-vacancy will be allowed to relax and the energy minimized with respect to these relaxations. From the energy of formation of the di-vacancy and the change in the force constants, the concentration of di-vancancies as a function of temperature will be examined. The working part of the program will be a subroutine to simultaneously minimize an arbitrary function in up to 750 variables. (James Burton)

2780-79051 T Economics. The Effect of Interest Rate Changes on Capital Market Equilibrium. The problem is to ascertain which of various theories of the cost of capital provide the best a priori description of changed capital market equilibrium conditions when interest rates change. Mathematical methods to be used are econometrics and the analysis of variance and covariance. Data have been obtained from Moody's Utilities Manual, Standard and Poors Utilities and the Value Line Newsletter. The results will be used to give empirical evidence leading to the acceptance or rejection of the various theories for the purpose of a Ph.D. dissertation and subsequent publication. Econometric techniques are to be invoked according to the statistical problems, if any, which appear in tests of naive models using ordinary least squares or limited information methods of estimation. The number and scope of the calculations is so large and complex that non-computer methods would not allow the work to be completed. (E. P. Mampe)

2781-79052 Chemistry and Chemical Engineering. X-ray Structure Analysis of Crystals. The methods of X-ray crystal structure analysis are being used to investigate the molecular structure of a series of related compounds. Studies are proposed on some molecules related to ferrocene, particularly derivatives where bridging groups give the geometry a certain degree of rigidity. Metal carbonyl complexes of aromatic hydrocarbons are also being studied, particularly complexes with molecules containing seven and eight-membered rings. The methods being used include the heavy atom method and the direct phasing approach. Programs being employed are principally calculation of structure factors, evaluation of Fourier series, and least squares refinements. (I. C. Paul)

2782-79053 Education. The Values of Modernization. The Values of Modernization is an exploration of the value structure in a traditional, Islamic Nigerian community. In 1966, approximately 900 questionnaires were administered to a sample which was generally stratified according to age, sex, education, and place of residence - the independent variables. The dependent variables are modernity, religiousity, and alienation.

Following are examples of the questions raised by the study which guide the analysis of the data: (1) What is the flow of values in the community on a traditional-modern continuum? What modern values are appearing among the population and what traditional values are remaining intact? (2) Is modernity a single or a multi-dimensional factor? (3) What is the association between modernity, religiousity, and alienation? (4) What effect does Western education have on the shaping of values? (5) How does urbanization relate to an individual's value structure?

Analysis of the data will involve the following types of computations: factor analysis, varimax rotation, measures of association (multiple and partial correlation), analysis of variance, and cross-products matrices. (Alan Peshkin)

2783-79060 Physics. Nuclear Charge Distribution Analysis. The problem consists of two parts, pertaining to the two separate experimental techniques which are analyzed to determine nuclear charge distributions. The first, an analysis of high-energy electron scattering experiments, is a partial-wave analysis of the Dirac equation continuing the Coulomb potential of an adjustable nuclear charge distribution. Most of the computation time is spent on numerical integration of the radial Dirac equation, which takes the form of two coupled first order differential equations. In the final stage, summation of a Legendre series containing the phase shifts involves considerable cancellation, so that double-precision arithmetic is used. The second part concerns x-rays emitted during the decay of muonic atoms. The precise energies of the x-rays are sensitive to nuclear charge distributions. The computation involved is the eigenvalue problem with virtually the same Dirac equation as in the first part. A first-order prediction gives convergence of the eigenvalues to about seven places in about five trials. (D. G. Ravenhall)

2784-79061 T Civil Engineering. Optimal Truss Configurations. The goal of this investigation is the development of a technique for determining the optimal (least weight and/or cost) geometrical configuration for planer truss systems subjected to loadings commonly encountered in bridge and roof construction. Cost of joints and possibly buckling constraints will be included. (Harry Jones)

2785-79062 Materials Research Laboratory. Ising Model Correlations. Correlation functions within an Ising model are calculated by using a stochastic model for relaxation to thermodynamic equilibrium. The spins on a 32 by 32 lattice are allowed to exchange when nearest neighbors can interchange without changing the total Ising model energy. Spins are shown at random and simple tests are applied to learn whether the interchange is allowed or forbidden. After any exchange the system relaxes to thermodynamic equilibrium. Then it is possible to calculate correlations among the spins on different sites in the lattice. (L. Kadanoff)

2786-79063 Materials Research Laboratory. Triplet Exciton Dynamics. Matrix elements which occur in the theoretical description of the migration and annihilation of triplet excitons in polyacene crystals are evaluated using universal tables of self-consistent carbon-carbon coulomb, hybrid, and exchange integrals previously computed at various intermolecular distances. Values of the integrals at distances other than those in the input tables are obtained by interpolation. The output data allows for evaluation of the triplet exciton hopping time, annihilation rates, and diffusion tensor. (Charles Swenberg)

2787-79064 Special Education. Dissemination Project. This project is concerned with the impact of special programs in selected public schools in Illinois. It will attempt to determine the effectiveness of dissemination activities in that system on the pupils and teachers in the system. The objectives of this project are to identify elements that enhance and/or inhibit dissemnation in that system. Data will be collected by fulltime interns in the local districts and submitted to the project office for processing. SSUPAC programs will satisfy most analysis requirements. Computer results will be shared with the local schools to give them substantive background for educational assessments and decisions. This is a pilot training and research program supported by a grant from the U. S. Office of Education. (W. D. Simmons)

2788-79073 Materials Research Laboratory. Thermal Conductivity of Insulators. The object of this calculation is to find a reliable way of calculating the thermal conductivity of insulating solids due to three phonon interaction processes. The computer will be used to investigate different approaches to the problem. One such approach will be to calculate phonon lifetimes in perturbation theory due to the anharmonicities. Particular attention will be paid to the importance of anisotropy in the harmonic phonon spectrum since Herring has demonstracted that this can be of dominant importance in the calculation of thermal conductivity. (Hilary Jones)

2789-79075 Forestry. Forest Tree Improvement Research. Analysis of Forest Treee Improvement Research involves analysis of variance, correlation, regression, and other statistical computations. In the Forestry Department, research is presently being conducted on Scotch pine, cottonwood, larch, Douglas-fir, and other species. Data are usually obtained by field measurements of such characteristics as heights, diameters, and forms. In certain cases, other traits - color, branch angle, disease resistance, etc. - may be measured. The results of computer operations on such data are used to determine superior varieties for specific traits, or even for several correlated traits. The selected varieties are then disseminated. (J. J. Jokela)

2790-79076 T Forestry. Genetics of Eastern Cottonwood. The computations for this project will primarily be analyses of variance, solution for variance components, calculation of correlation and regression coefficients. Other statistical values will undoubtedly be computed as well. The traits of eastern cottonwood to be studied are heights, disease resistance, and form, as well as minor traits such as branch angle. This particular study is particularly valuable since data have been collected since 1960, making this plantation the only one to have such a set of measurements. One goal of the study is the selection of cottonwoods which are more disease resistant, more vigorous, more suitable for pulpwood production. Another objective is the determining of the relationship, if any, between growth and disease resistance. (D. L. Rockwood)

2791-79078 Physics. Elementary Particle Equations. A study of the properties of approximations to the equations of relativistic quantum field theory is planned. In particular the Bethe Salpeter equation will be studied for more general potentials than simple ladder graphs. Also the nature of approximations to the relevant dispersion relations will be studied. (Jon Wright)

2792-79079 T Accountancy. Financial Study of the Meat Packing Industry. The research problem, in part, will contain a ratio analysis of twenty financial ratios for nine meat packing companies. These will be incorporated into the main body of the thesis. Data was obtained from Moody's volumes, American Meat Institute Publications, and Annual Reports of the various companies. The computer results have been used in the writing of the chapter on a financial analysis. (Cameron Carley)

2793-79080 T Psychology. Level of Aspiration and Performance at a Simple Motor Task as a Function of Sex of Experimenter, Sex of Subject, and Reinforcement Condition. This is an investigation of the effects that the sex of the experimenter, the sex of the subject, and the reinforcement condition (approval, no comment, and disapproval) have on the level of aspiration and the performance at a simple motor task of fifth grade boys and girls in the public elementary schools. The data will be analyzed in a three-way and a four-way fixed effect analysis of variance and also as a within subjects in a mixed analysis of variance. The data were obtained from fifth grade boys and girls in the Urbana schools who played a marble sorting game for ten minutes under two of the three reinforcement conditions and gave three level of aspiration ratings during this time. The results will be used in the thesis research of the investigator. (Soderman)

2794-79082 Zoology. Fluctuations in Animal Populations. Monthly fluctuations in populations of invertebrate animals and annual fluctuations in bird and mammal numbers have been measured since about 1934 in Trelease, Brownfield, and Funks Woods. These data will be analyzed relative to monthly variations of each species through the year and from year to year. Multiple correlations will be made between the animal populations and temperature, precipitation, solar radiation, vegetation, and other environmental factors. (S. L. Kendeigh)

2795-79085 Physics. Overlapping Resonances in Three Particle States. In the theory of final state interactions among three particales extra singularities occur in the scattering amplitude if more than one two-particle resonance is energetically allowed. Very little quantitative information is available on the importance of these singularities. The integral equations governing these singularities can be solved numerically on the 7094 by matrix inversion after special attention has been given to the form of the singularities. The results will have implications for many reactions in both high and low energy nuclear physics. (R. L. Shult)

2796-79086 Materials Research Laboratory. Least Square Fit of Experimental Data. The object of this problem is to fit the experimental data on the heat capacity of copper, near its critical point, to an exponential and a logarithmic curve by the method of "least squares". The specific heat diverges near the critical temperature. The object of the present analysis is to see the functional form of specific heat near the critical temperature. (A. Sadiq)

2797-79089 T Physiology. Bioenergetics and Thermoregulation of the Snowy Owl. The snowy owl is a predator on lemmings in the Arctic tundra of northern Alaska where this study will be carried out. Measurements will be made of the gross energy intake as food, the excretory energy loss, and the energy metabolized for existence of caged birds over the entire range of ambient temperature that the species will tolerate. Regression analyses will be performed on these energy measurements vs. ambient temperature. In addition, body core temperatures, subcutaneous temperatures, and temperatures at the base of the feathers will be recorded in caged birds in order to calculate the rate of heat loss from the bird at different temperatures and wind velocities. This study will furnish information on how this species is physiologically adapted and on the rate of energy flow through certain steps in the tundra eco-system. (James Gessaman)

2798-79092 Electrical Engineering. Distances and Space Densities of Planetary Nebulae. Following the theory of Shklovsky, the distance of a planetary nebula from the earth is determined from the solution of an implicit equation which corrects for interstellar extinction according to a model of interstellar dust distribution in the galaxy. Hydrogen Balmer line fluxes, angular diameters, and galactic coordinates of over 500 planetary nebulae enable statistically significant distances for these nebulae to be calculated. From these distances, local densities may be determined. The computer is subsequently used to plot the galactic districutions of the nebulae, to calculate the interstellar extinction, and to calculate the local nebular densities. (Julius H. Cahn)

2799-79093 T Psychology. Workers' Backgrounds, Attitudes, Behaviors, and Value Systems. This research is an examination of the influence of workers' cultural backgrounds on their personal work value systems. Further, it studies the possibility of using biographical data and/or value systems as moderators in predicting workers' job performance and job attitudes. A pretest sample of 200 airmen and a main sample of 800 airmen will be used with data being collected by questionnaire. Moderator analyses will be done by the quadrant technique. In studying value system differences, multiple analysis of variance procedures will allow comparison of both centroids and dispersion matrices. The sample will be divided on the basis of moderators, and covariance matrix comparisons will be done for selected variable relationships. (M. R. Blood)

2800-79097 T Zoology. Tooth Size Selection in Mus Musculus (House Mouse). The research project deals with selection of tooth size in Mus musculus (house mouse). The measurements are performed on a live, anesthetized animal with a micrometer caliper. The upper M1 (first molar) will be measured. After breeding the adults will be killed and correlated responses in dental characters will be measured with a Gaertner travelling microscope. Other correlated responses including body size will be taken at the time of selection. It will be necessary to treat the breeding plan with coancestry analysis to produce the maximum avoidance of inbreeding. Each generation

must be treated with an analysis of variance in order that the response to selection, the selection differential and the intensity of selection might be calculated. Also necessary to calculate are the cumulative selection differential and the values of the correlated responses. The results will be published. (Pinkham)

2801-79101 T Chemistry and Chemical Engineering. Interferometer Data Reduction. The output of a Michelson interferometer as used in Fourier transform spectroscopy is a complex amplitude-time function called an interferogram. The interferogram and the spectrum of the source form a Fourier transform pair. Thus in order to obtain the desired spectrum, the Fourier transformation of the interferogram must be taken. The average level of the interferogram is first subtracted from it to remove the d.c. component. Next, the interferogram is apodized with an appropriate function. The discrete Fourier transformation is then taken with the Cooley-Tukey algorithm and the amplitude spectrum is calculated from the sine and cosine coefficients. (Gary Horlick)

2802-79106 T Economics. Industrial Linkages and Agglomeration. The purpose of this research project is to measure the impact of industrial linkages on the geographic concentration of industries. Two industries are said to be linked if one is an important buyer from, or seller to, the other. The geographical basis for this project will be the 57 largest standard metropolitan statistical areas of the United States. For each area the number of manufacturing employees will be counted for each of the 51 manufacturing sectors of the 1958 input-output study as published by the Deparment of Commerce. Correlation analysis will be used to determine the degree of geographical association between each industry pair. By comparing the correlation matrix with the input-output table, the relationship between industrial linkages and agglomerations and economic activities will be investigated. The data were obtained from the 1958 Census of Manufacturers. (C. E. Richter)

2803-79111 T Physics. Critical Indices. Exact high temperature expansions of the spin-spin correlation functions of certain magnetic models will be derived and analyzed to determine the effect of exchange anisotropy on the critical indices associated with the phase transition. The method of Padé Approximants will be used extensively, requiring the finding of roots of complex polynomials, and frequent matrix operations. (David Jasnow)

2804-79115 Civil Engineering. Effect of Raindrop Impact on Sheet Flow. This research project concerns an analytical and experimental study of the effect of raindrop impact on sheet flow. This knowledge will be useful in the design of drainage systems in urban areas where this type of flow is common. The computer will be employed in both phases of the study. The mathematical equations describing the flow are first order, quasi-linear partial differential equations whose solution requires numerical techniques. Experience has shown that instabilities in the solution may exist under certain conditions and therefore various explicit and implicit difference schemes will be tried. In addition, experimental data consisting of flow and depth-time measurements will be taken using a tape recorder to record the electronic output of the sensors. This data will be reduced and analyzed using the computer. (H. G. Wenzel)

2805-79116 General Engineering. Radon-222 Analysis. The problem is to calculate the activity of Radon-222 at the time when it was collected. The program makes appropriate allowances for losses due to decay between the time of collection and transfer and for further decay between transfer and counting. In the interval between transfer and counting daughters of Radon-222 accumulate in the counting bottle and calculations provide for their accumulations. (J. E. Pearson)

2806-79117 Civil Engineering. Durability of Concrete. Means for improving the durability of portland cement concrete through improved curing procedures are being investigated. Freezing and thawing tests are being conducted on concrete and mortar specimens subjected to varying amounts of air drying at various times in the curing cycle. Deterioration of the specimens during freezing and thawing tests is being measured by changes in specimen weight and changes in relative dynamic modulus. Possible adverse

effects of air drying on the compressive strength and abrasion resistance of concrete are also being investigated. The results will be used as a basis for recommendations concerning optimum curing conditions for portland cement concrete. The computer will be used to perform computations on the experimental data to obtain values of relative dynamic modulus, compressive strength, and abrasion coefficient. Statistical information from the experimental results, such as the standard deviation and coefficient of variation, will be computed to aid in the analysis of the results. (Clyde L. Anderson)

11.2 Instructional Problem Specifications

During the third quarter of 1967, 6 instructional problem specifications were submitted to the Department for computation. The following brief descriptions of these problems have been prepared for inclusion in this report by those submitting them.

I706-77056 Political Science 447. Indian Attitudes Toward Their Military. The data to be used for this problem consists of interview data obtained from an attitude survey of 2000 Indians. The procedure will be to correlate attitudes toward the Indian army held by these respondents with other attitudes on political and social problems, and with personal background data--for example, occupation, religion, education, and party affiliation. Frequency counting and correlation programs will be utilized to obtain a statistical profile of those Indians who would be in favor of military government, and those who would be opposed. (Stephen P. Cohen)

I733-79020 Aeronautical and Astronautical Engineering 241. I have a large trajectory simulation program which has some parts in 7094 machine language. I need a resource of one hour of 7094 time while transitioning the program to the 360. Basically the student programs will be parametric studies of analytic solutions of the design problem. (A. G. Bennett)

I743-79036 Political Science 496. Political Concepts - Formulation and Measurement. Students in Political Science 496 perform secondary analysis of data supplied by the Inter-University Consortium for Political Research located in Ann Arbor, Michigan at the University of Michigan. This data usually comes to us on tape and it would be highly advantageous to us to secure permission to hang tapes on the class number.

In the past, we have used the facilities at Commerce West to convert the tapes to cards. The work decks generated by this means were then submitted on the 7094. However, often, as indeed the case was last semester, the facilities at Commerce West cannot keep up with the volume of work generated by their own classes and have been unable to respond to our needs until late in the semester. This resulted in a number of students incurring incomplete grades. Needless to say, this

did not make for a very desirable situation, and the use of the 7094 to run tapes would eliminate this incumberance.

One additional fly in the ointment should be observed. Our tapes are not entirely 800 BPI, some are 556 BPI. If we could secure permission to translate the most used tape from 556 to 800 BPI and to then hang this tape for the purposes of the class analysis, many of our previous difficulties will have been surmounted. (A. H. Miller)

I755-79050 Zoology 210. Computafly for Zoology 210. Two printouts are given to each student. Each printout uses the random number generator to simulate a population of "evolving" computaflies. Thus, each student has his own population. Associated with each student's printout is an instructor's printout of the statistics of the current simulation. (Tenczar)

I763-79066 Aeronautical and Astronautical Engineering 264. Reduction of Experimental Data. This set of computations deals with the reduction of sets of experimental data and performing least square fits in order to deduce theoretical and empirical relations. (H. H. Hilton)

I767-79070 Nuclear Engineering 495. Calculation of Gamma Flux Using Advanced Methods. The problem is to compute gamma ray fluxes, differential in angle and energy, in the vicinity of a plane isotropic source imbedded in an infinite medium. The moments method of Spencer and Fano will be used, and if time permits, Monte Carlo methods will also be employed. The purpose of the problem is to help the student gain experience and facility with the use of the above-mentioned computational techniques. (A. B. Chilton)

11.3 Blanket Class Problem Specifications

During the third quarter of 1967, 97 problem specifications were submitted to cover all assigned problems in the following courses.

J694-77004	Electrical Engineering 389.
J695-77005	General Engineering 010.
J696-77006	Civil Engineering 262.
J697-77008	Theoretical and Applied Mechanics 311.
J698-77009	Mechanical Engineering 260.
J699-77010	Electrical Engineering 251.
J700-77014	Aeronautical and Astronautical Engineering 391.
J701-77028	Civil Engineering 497.
J702-77030	General Engineering 293.
J703-77039	Computer Science 101.
J704-77040	Computer Science 101.
J705-77052	Civil Engineering 473.
J707-77058	Industrial Engineering 282.
J708-77062	Marketing 380.
J709-78008	Mechanical Engineering 264.

J710-78009	Mechanical Engineering 263.
J711-78010	Mechanical Engineering 214.
J712-78011	Chemistry and Chemical Engineering 490.
J713-78013	Educational Psychology 497.
J714-78020	Agricultural Economics 341.
J715-78021	Agricultural Economics 325.
J716-78022	Agricultural Economics 325.
J717-78032	Computer Science 201.
J718-78035	Aeronautical and Astronautical Engineering 426.
J719-79002	Graduate School of Business Administration 544.
J720-79003	Graduate School of Business Administration 590.
J721-79004	Mechanical Engineering 259.
J722-79005	Mechanical Engineering 260.
J723-79006	Chemistry and Chemical Engineering 348.
J724-79007	Graduate School of Business Administration 532.
J725-79008	Graduate School of Business Administration 545.

J726-79009	Chicago Circle Physics 371.
J727-79010	Computer Science 109.
J728-79014	Economics 476.
J729-79016	Mechanical Engineering 306.
J730-79017	Chemistry and Chemical Engineering 367.
J731-79018	Chemistry and Chemical Engineering 466.
J732-79019	Computer Science 387.
J733-79021	Agronomy 365.
J734-79022	Anthropology 220.
J735-79023	Mechanical Engineering 256.
J736-79024	Civil Engineering 391.
J737-79025	Civil Engineering 262.
J738-79027	Geography 370.
J739-79030	Accountancy 373.
J740-79032	Mechanical Engineering 271.
J741-79033	Educational Psychology 490.
J742-79034	Electrical Engineering 250.

J744-79037	Nuclear Engineering 455.
J745-79038	Electrical Engineering 323.
J746-79041	Engineering Honors 297.
J747-79042	Mechanical Engineering 224.
J748-79043	Civil Engineering 461.
J749-79044	Theoretical and Applied Mechanics 314.
J750-79045	Civil Engineering 391.
J751-79046	Education 241.
J752-79047	Civil Engineering 302.
J753-79048	Graduate School of Business Administration 573.
J754-79049	Graduate School of Business Administration 571.
J756-79054	Chemistry and Chemical Engineering 394.
J757-79055	Chemistry and Chemical Engineering 392.
J758-79056	Civil Engineering 361.
J759-79057	Mechanical Engineering 341.
J760-79058	Mechanical Engineering 221.
J761-79059	Electrical Engineering 322.
J762-79065	Architecture 456.
J764-79067	Sociology 385.

J765-79068	Physics 303.
J766-79069	Chemistry and Chemical Engineering 341.
J768-79071	Mechanical Engineering 406.
J769-79072	General Engineering 231.
J770-79074	Mechanical Engineering 186.
J771-79077	City Planning 376.
J772-79081	Electrical Engineering 386.
J773-79083	Civil Engineering 316.
J774-79084	Geology 493.
J775-79087	Computer Science 301.
J776-79088	Agricultural Engineering 311.
J777-79090	Mechanical Engineering 445.
J778-79091	Aeronautical and Astronautical Engineering 451.
J779-79094	Chemistry and Chemical Engineering 421.
J780-79095	Electrical Engineering 296.
J781-79096	General Engineering 288.
J782-79098	Civil Engineering 297.
J783-79099	General Engineering 241.
J784-79100	General Engineering 242.

J785-79102	Theoretical and Applied Mechanics 493.
J786-79103	Theoretical and Applied Mechanics 311.
J787-79104	Theoretical and Applied Mechanics 451.
J788-79105	Civil Engineering 368.
J789-79107	Psychology 493.
J790-79108	Psychology 390.
J791-79109	Electrical Engineering 415.
J792-79110	Nuclear Engineering 401.
J793-79112	Electrical Engineering 451.
J794-79113	Civil Engineering 497.
J795-79114	Aeronautical and Astronautical Engineering 261.

12. GENERAL LABORATORY INFORMATION

12.1 Personnel

The number of people associated with the Laboratory in various capacities is given in the following table:

	Full-time	Part-time	Full-time Equivalent
Faculty	18.0	4.0	20.39
Visiting Faculty	3.0	1.0	3.67
Research Associates	1.0	----	1.0
Graduate Research Assistants	8.0	96.0	53.1
Graduate Teaching Assistants	----	2.0	0.83
Professional Personnel	22.0	3.0	23.75
Administrative and Clerical	21.0	1.0	21.5
Nonacademic Personnel (Monthly)	71.0	1.0	71.5
Nonacademic Personnel (Hourly)	1.0	87.0	34.3
TOTAL	145.0	195.0	230.04

The Computer Advisory Committee consists of Professor J. R. Pasta, Head of the Department; Professor J. N. Snyder, Associate Head of the Department; Professors L. D. Fosdick, H. G. Friedman, C. W. Gear, D. B. Gillies, D. J. Kuck, B. H. McCormick, S. Muroga, T. A. Murrell, J. Nievergelt, R. S. Northcote, J. R. Phillips, W. J. Poppelbaum, S. R. Ray, J. E. Robertson, P. E. Saylor, and D. L. Slotnick.

12.2 Bibliography

During the quarter, the following publications were issued by the Laboratory.

File Numbers

(1) Engle, J. T., "Basic Syntax of PL/1 and EPL," File No. 736, August 25, 1967.

(2) Flowerdew, S. J., "Left: A Language for Editing and Formatting Text," File No. 737, September 29, 1967.

(3) Kelley, Karl, Ray, Sylvian R., and Stahl, Fred, "Information Search Language," File No. 735, September 12, 1967.

Report Numbers

(1) Esch, J. W., Irwin, A. F., Kubitz, W. J., Oberbeck, P. E., Poppelbaum, W. J., and Rollenhagen, D. C., "Artrix Final Report," Report No. 238, June 20, 1967.

(2) Hazelhurst, J. H., McCormick, B. H., and Bond, W. D., "The Web System. Part 1: The Utilization of Web," Report No. 243, September 11, 1967.

(3) Lukaszewicz, Leon and Nievergelt, Jurg, "EOL Report," Report No. 241, September 1, 1967.

(4) Lukaszewicz, Leon and Nievergelt, Jurg, "EOL Programming Examples," Report No. 242, September 1, 1967.

(5) McInnes, A. W., "The Translator Generator System," Report No. 237, July 12, 1967.

(6) Muroga, S., Tsuboi, T., and Baugh, C. R., "Enumeration of Threshold Functions of Eight Variables," Report No. 245, August 2, 1967.

(7) Robertson, James E., "A Deterministic Procedure for the Design of Carry-Save Adders and Borrow-Save Subtracters," Report No. 235, July 5, 1967.

Specification Numbers

(1) Casasent, David and Sand, Douglas, "Specifications for a Photometric Microscope Assembly," File No. 550-102, July 10, 1967.

(2) Krabbe, S. Paul, "Specification for A 54 Pin Printed Circuit Board Connector (Contacts accept Wire Wrap and/or Termi Point Connections)," File No. 550-105, September 5, 1967.

(3) McCormick, Bruce H., "Specifications: High Resolution Closed Circuit Television Equipment for a System of Ten Remote Video Consoles," File No. 550-104, August 18, 1967.

(4) Rollenhagen, David, "Specifications for Closed Circuit Television Camera with Provisions for External Control of the Beam Deflection," File No. 550-103, July 20, 1967.

Theses

(1) Bunting, Marcus L., "Optimization of the Bridged-T Network Using Computer Techniques," (M.S.), Report No. 239, August 15, 1967.

(2) Hecht, Robert W., "Storage Allocation Module for a Time Sharing System," (M.S.), Report No. 247, September 19, 1967.

(3) Henderson, Dugold Austin, Jr., "A Graphics Display Language," (M.S.), Report No. 240, August 21, 1967.

(4) Jordan, Harry F., "Three Particle Effects in the Pair Distribution Function for the HE^4 Gas," (Ph.D.), Report No. 248, September 25, 1967.

(5) Katoh, Takehiko, "Steering Circuitry for an Electroluminescent Panel," (M.S.), Report No. 236, May 18, 1967.

(6) McDowell, Leland K., "Variable Successive Over-Relaxation," (Ph.D.), Report No. 244, September 18, 1967.

(7) Otis, Alton Benjamin, Jr., "An Analog Input/Output System for the Illiac II," (M.S.), Report No. 246, September 22, 1967.

(8) Rohr, John R., "Major and Minor Threshold Functions of Six Variables," (M.S.), Report No. 234, June 17, 1967.

12.3 Colloquia

"Type Composition--Past, Present and Future," by Mr. L. L. deLorimier, IBM Corporation, Chicago, Illinois, September 18, 1967.

"Intrinsic Multiprocessing," by Mr. R. Aschenbrenner, Mechanical Research, Inc., Minneapolis, Minnesota, September 25, 1967.

12.4 Drafting

During the quarter, a total of 1,014 drawings were processed by both drafting sections:

	General	Pattern Recognition
Large Drawings	37	42
Medium Drawings	45	13
Small Drawings	390	--
Layouts	12	247
Report Drawings	--	43
Change Order Drawings	159	19
Miscellaneous	27	--
TOTAL	670	344

(M. Goebel, J. Otten)

12.5 Shops' Production

Job orders processed and completed during the third quarter of 1967 are as follows:

Facility	AEC 1018	AEC 1469	Other
Machine Shop	30	36	20
Electronics Shop	37	21	2
Etch Shop	8	23	17
Layout Shop	15	17	6

Wiring of 612 standard printed circuit boards, 255 Stalactite Assemblies, and 233 Stalactite Chips accounted for 23,973 diodes and 12,485 transistors used during this period.

(F. Serio)

Physics

QUARTERLY TECHNICAL PROGRESS REPORT

October, November, December 1967

DEPARTMENT OF COMPUTER SCIENCE · UNIVERSITY OF ILLINOIS · URBANA, ILLINOIS

QUARTERLY TECHNICAL PROGRESS REPORT

October, November, December 1967

Department of Computer Science
University of Illinois
Urbana, Illinois 61801

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1. CIRCUIT RESEARCH PROGRAM

(Supported in part by the Office of Naval Research under Contract NR 048-102/6-15-67 Code 437, W. J. Poppelbaum, Principal Investigator).

Summary

The Phastor project has been completed and Larry Wallman is engaged in writing the final report to be published shortly.

The present progress report also sees the final contribution in Chushin Afuso's marathon series on Random Sequence Coding. The editor hopes he will be forgiven for a possibly improper use of this summary in adding a personal note of gratitude to (now) Dr. Afuso for the clarity of thought and exposition that has unfailingly characterized his reports (other contributors please follow). This work is currently being extended by John Esch into the realm of stochastic computers.

Tak Katoh has redesigned the driver for the Electroluminescent Panel.

Bill Steiner reports on significant progress with the circuitry for Potentiomatrix.

Finally, a new project for a Large Screen Display has been started by Bob Wickersheim, who recently joined the group.

1.1 Random Sequence Coding (Project No. 03)

1.1.1 Experimental Results for Adder, Subtracter and Divider

Experiments have been done for the adder, subtracter and divider. In order to see the variation in accuracy due to the capacity of the counter, which is employed in all three units as the temporary storage, the number of stages of the binary counter was varied. Experimental results agree well with theoretical estimates. For all three units three binary stages provide adequate storage capacity in practice. The details are to be found in Report No. 255 (author's thesis).

1.1.2 Squaring Unit

In Synchronous Random Pulse Sequences (SRPS), if the occurrence of a pulse in a time slot is independent of any previous occurrence, the pulse distribution is described by a binomial distribution function. Delaying such an SRPS by one clock period produces another SRPS with the same average repetition rate, which is uncorrelated with the original SRPS. If the delayed SRPS and the original SRPS are applied to a multiplier (AND gate), the output of the multiplier gives the square of the input machine variable value.

Realization of such a squaring unit is simple once a delaying unit is available. Naturally, proper operation of the squaring unit depends on the pulse distribution of the input SRPS.

The experimental unit of the squaring unit was built and tested. The results of the experiments are interesting not only to confirm the theory of the squaring unit itself, but also to observe characteristics of the pulse distribution of the input SRPS. Details are given in Report No. 255.

It was found that the assumption of a binomial distribution for the pulse distribution did not hold true strictly for the actual SRPS generators. However, deviation from the binomial distribution may be practically eliminated by eliminating storage action in the circuit of the SRPS generator. The circuit for an SRPS generator improved in this way is presented in the next section.

1.1.3 An Improved Circuit of the SRPS Generator

A circuit of the SRPS generator is shown in Figure 1.

The capacitors at the base and emitter of T_4 should not be increased very much. Large capacitors at these points produce a large equivalent capacitor at the base of T_3. Since the base of T_2 is more or less directly connected to the base of T_3, a large capacitance (or equivalent) at the base of T_3 must be avoided.

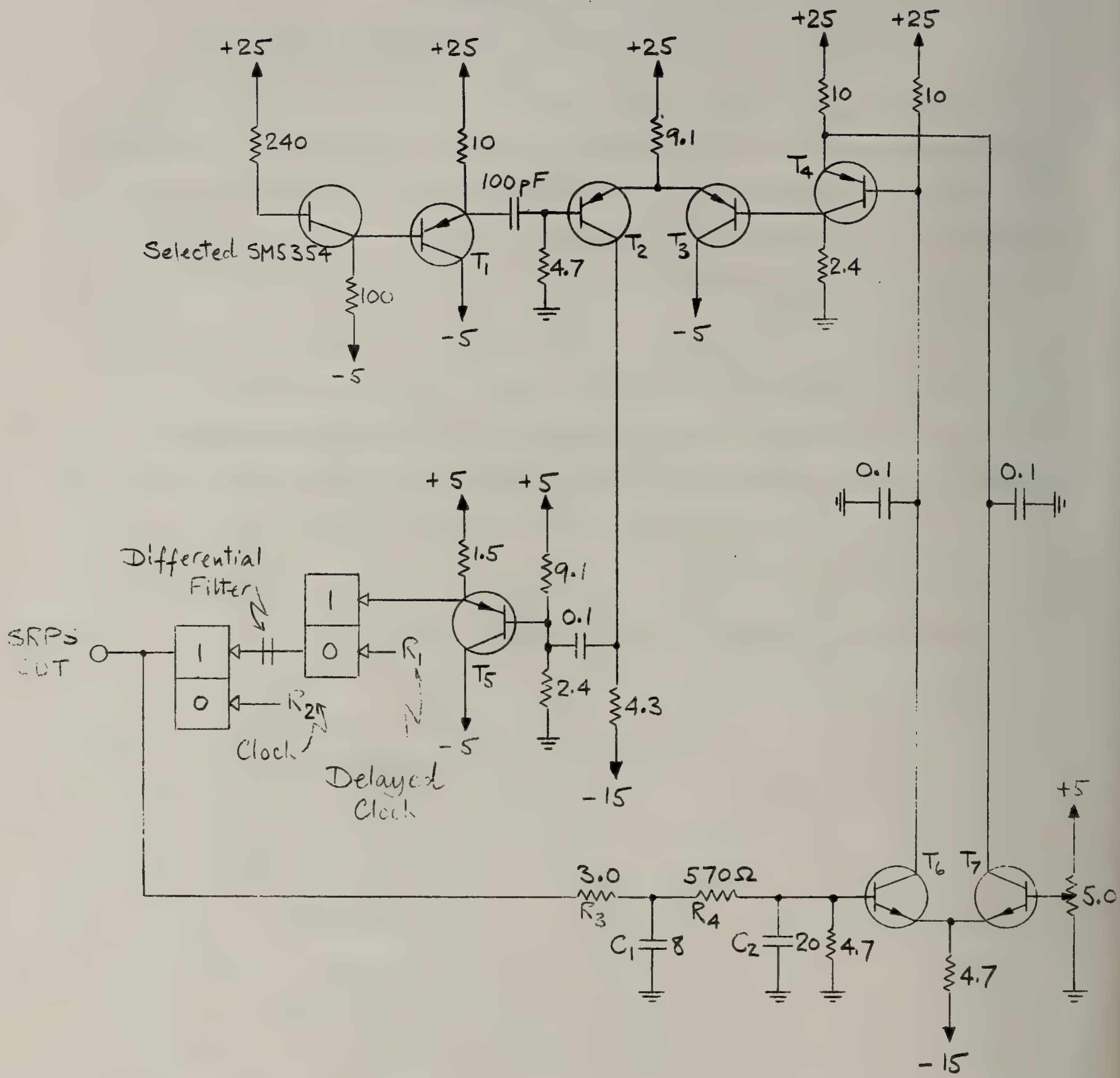
R_3, R_4, C_1, and C_2 must be determined by the desired value of the averaging time.

For proper operation at the microplasma condition, the total supply voltage applied on SM 5354 (selected unit) should be at least 30 volts. DC standing current of about 30 μa (through the base-to-collector junction of SM 5354) seems optimum for stable noise generation.

T_1, T_2, T_3, and T_5 must be fast enough so that noise pulses are not destroyed.

The collector-to-base capacitance of T_4 must be small enough to eliminate storage action through the base of T_3.

Chushin Afuso



Unless otherwise stated:

Resistances in kΩ

Capacitances in μF

Figure 1. SRPS Generator Circuit

1.1.4 Summary of Research to Date on Clocked Random Pulse Sequences

The number which a CRPS represents is equal to the normalized average number of pulses that occur during some sampling time. Because this number is normalized its range is [0,1] and because the pulses occur randomly this number is equal to the probability that a pulse will occur during any given clock period.

How such a CRPS can be generated is illustrated in Figure 2. It is important that the noise be both random in amplitude and time. If A is a CRPS with probability a of a pulse occuring, then $\overline{A}$ (logical not of A) has probability (1-a) of a pulse occuring = the probability that a pulse does not occur in A. Thus, if the sampling unit is a clocked flipflop, its outputs correspond to a (the probability of a pulse occuring) and 1-a.

From probability theory, the product of two independent probabilities is the probability that both CRPS's have pulses; but this is just the logical AND of the two sequences. Generalizing, one can multiply n CRPS's with an n input AND gate if all n inputs are independent. Because the occurrence of a pulse in each clock period is independent of its neighboring clock periods, one can delay a CRPS one clock period with a flipflop and obtain a new CRPS independent of the original but with the same value. This property allows one to raise a number to the nth power by delaying it (n-1) times and putting all n results into an AND gate.

Addition of CRPS-A to CRPS-B is forcing the result to have a normalized average number of pulses equal to the sum. If A and B are disjoint, A v B will give the sum directly. If A and B are not disjoint, then when A and B are both a "1", we increase an up-down counter by one and when neither A nor B is a "1", output a pulse and reduce the counter by one (unless it is zero). To subtract CRPS-B from CRPS-A we delete a pulse in A for each pulse that occurs in B. If B in some interval has more pulses than A, we store those excess pulses in an up-down counter as for Addition and later delete pulses of A while counting down the

number of pulses in the average period from one pulse to the next of a CRPS-A with probability a is equal to 1/a. Using this fact one can divide CRPS-B by CRPS-A.

Because of the sampling technique used to generate a CRPS, the distribution of the number of pulses is binomial. Consequently, if the mean is Tfa where T is the sampling time, f the clocking frequency, and a the probability of a pulse occuring; then the standard deviation is $\sqrt{Tfa(1-a)}$. If T = 1 ms, f = 10 MHz and a = .5, then one standard deviation is 50 pulses, and since the mean is 5,000 pulses, the error is .1%.

We have designed and built digital circuits which perform all of the above mentioned operations and have obtained results within 1% of predicted values.

A system we are investigating incorporates all of the above operations into one programmable unit. This unit has two CRPS operand inputs, several coded control inputs, a resultant CRPS output, and power. The total number of leads is less than 14 so that the whole General Stochastic Computing Element (GSCE) could be integrated into one dual-in-line package. The system mentioned uses an array of these GSCE's with fixed interconnection of inputs and outputs. One can then program by a suitable algorithm the operations of all GSCE's in the array to produce any function of the operations included in the GSCE's.

Another system utilizes the best properties of CRPS's by solving a problem which requires many weighted linear sums. This is accomplished very easily as Figure 3 illustrates. The important point here is that all the products can be added with an OR gate because the minterms, being disjoint, insure that all products are disjoint.

John Esch

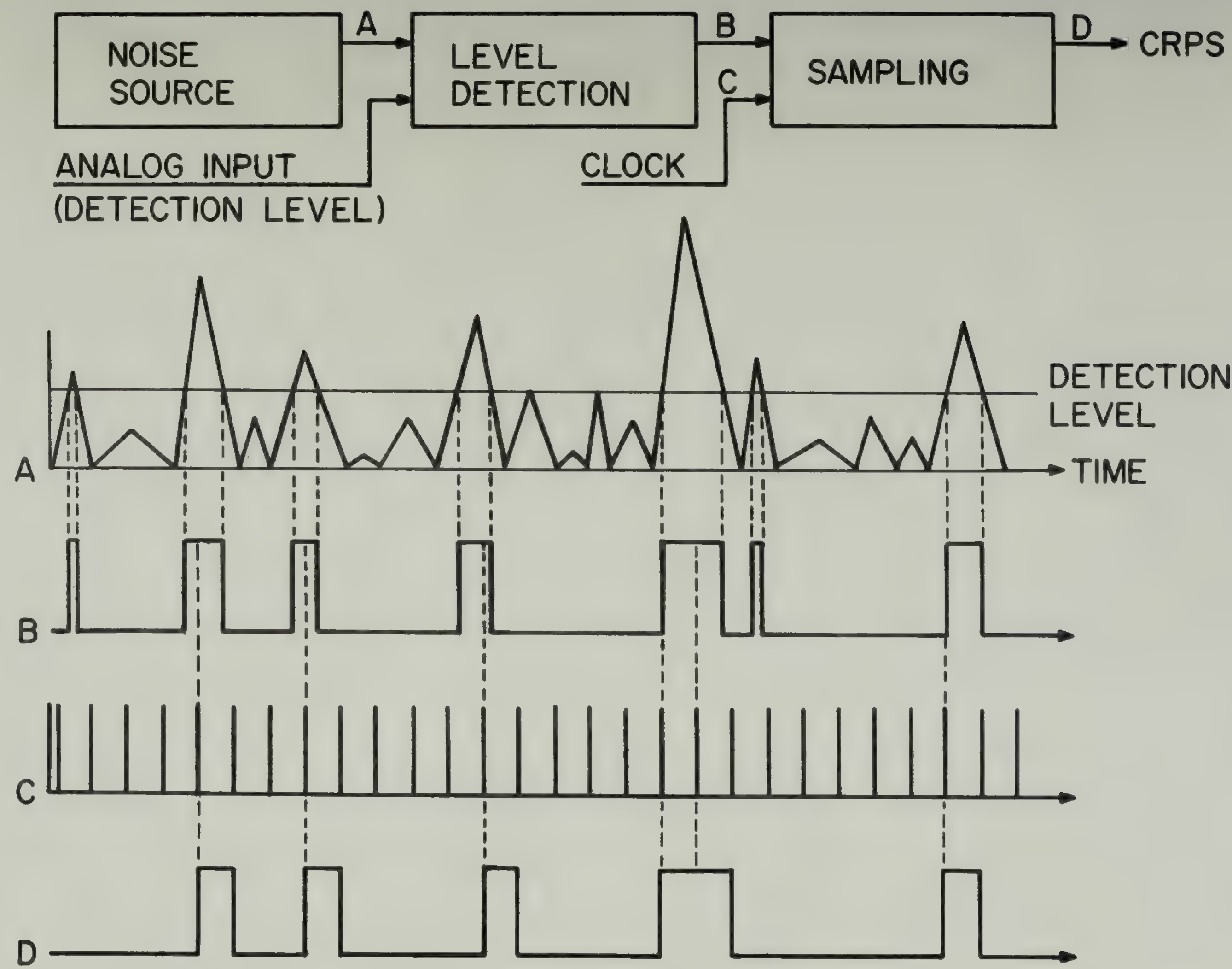


Figure 2. Simplified CRPS Generator

Figure 3. Linear Combinations

1.2. Electroluminescent Panel (Project No. 07)

1.2.1 Improved Driver

The driver for the electroluminescent panel has been redesigned to overcome the problem of the latter's high capacitance. This improved circuit, shown in Figure 1, contains two additional transistors, T_2 and T_4, to act as current sinks on turn off.

Tak Katoh

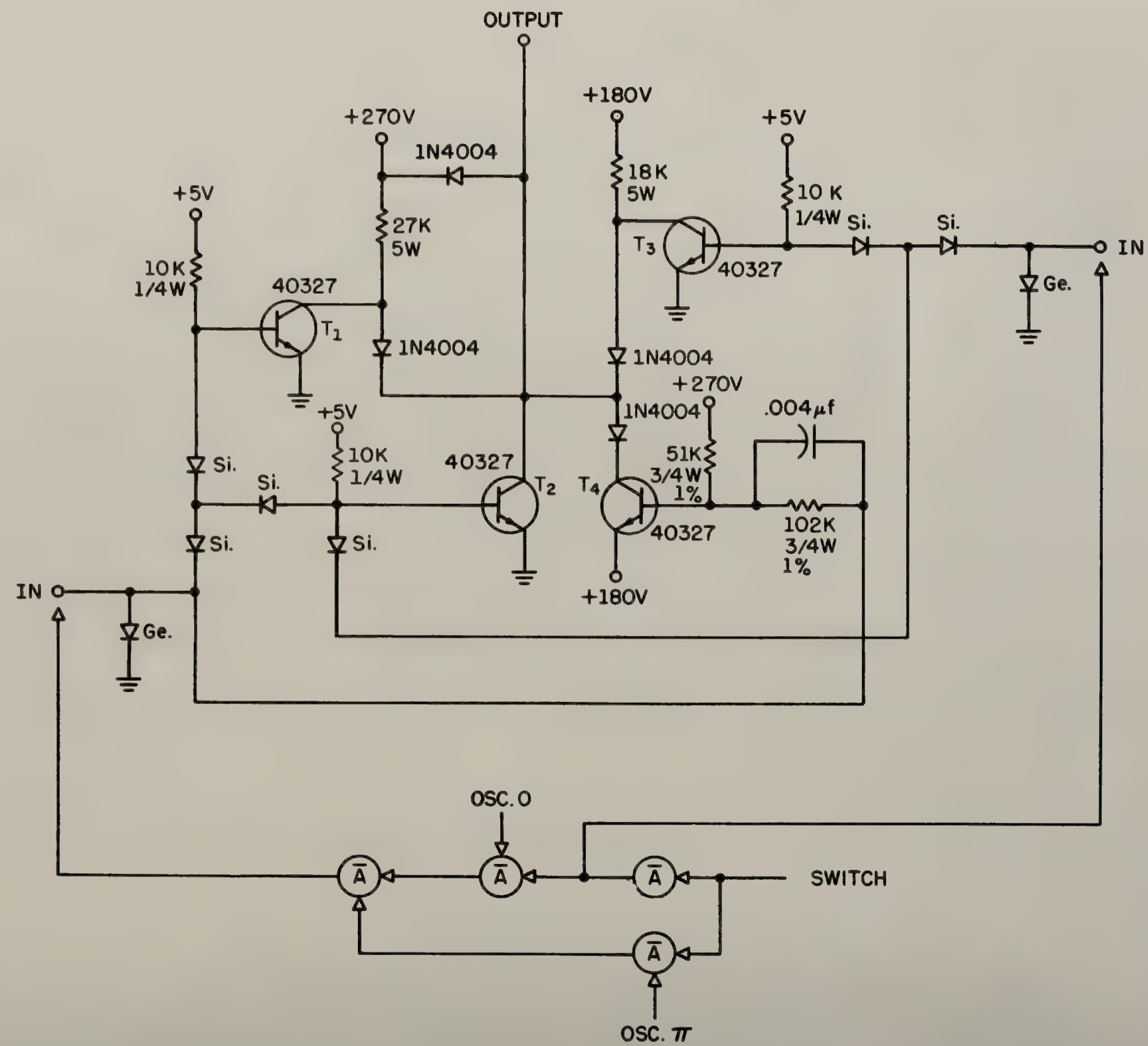


Figure 1. Electroluminescent Panel Driver

1.3 POTENTIOMATRIX (Project No. 08)

1.3.1 Improving the Driver Circuits

The two circuits of primary interest in Potentiomatrix are the READ circuit and the WRITE circuit. Any improvement on the characteristics of these circuits or any reduction in their costs pays handsome dividends because 1024 copies of each circuit are to be used in Potentiomatrix. The paragraphs which follow will describe both READ and WRITE circuits with improved characteristics, which also result in decreasing the cost of the Potentiomatrix project by nearly 50%.

1.3.2 READ Circuit

The function of the READ circuit is to determine whether the input voltage E_{in} is within an adjustable $\pm$ E volt of ground and, if so, to light a lamp. Electronically, this corresponds to the transfer function shown in Figure 1. It is generated by the novel modified bridges and the differential threshold detector shown in Figure 2.

The function of the modified bridge is demonstrated in Figure 3. Whenever the input voltage E_{in} is either greater than +E or less than -E, a pair of diodes conduct causing current to flow from top to bottom through the 56k resistors, in turn causing the upper terminal to be positive with respect to the lower terminal. However, whenever E_{in} is between +E and -E, all diodes are back-biased and the polarity on the 56k resistors is reversed by the small leakage currents which flow through the back-biased (germanium) diodes from +E to -E. The input resistance is seen always to exceed 156k and in the crucial region near E_{in} = 0v the input resistance becomes very much larger.

The differential threshold detector is a high gain differential amplifier which reacts to the polarity of the voltage across the 56k resistor. Its extremely high gain (8000 minimum) causes the amplifier to always be saturated at its high end or its low end and thus exhibit the digital output characterized by the transfer function shown in

Figure 1. The actual amplifier is a rather standard inexpensive integrated circuit built by General Electric.

The output of the detector is stored in the lamp driver storage element, a hybrid circuit which provides power gain to light the lamp and feedback for memory. When the lamp is off, this circuit draws zero power, and, when the lamp is on, the lamp itself consumes 90% of the power.

1.3.3 WRITE Circuit

The function of the WRITE circuit is to clamp its output to either +10v or -10v or allow its output to completely float, depending on the latest pulsed command on the input. The circuit reacts to inputs in the following way (Figure 4):

Input	Output
B1	Clamp +10v
0	Float
B2	Clamp -10v

Any input may be applied after any others so that these three commands correspond to selective write and selective erase on either output level.

The two transistors connecting the output form output drivers and isolating stages (a true float in the off state is quite important). The other four transistors form storage elements, which, like the lamp driver storage element, draw zero power in the off state. The emitters marked R1 and R2 are master resets which allow banks of such circuits to be reset simultaneously. The circuit has a built-in interlock so that it cannot be in two states simultaneously and has a high noise immunity at the input.

Bill Steiner

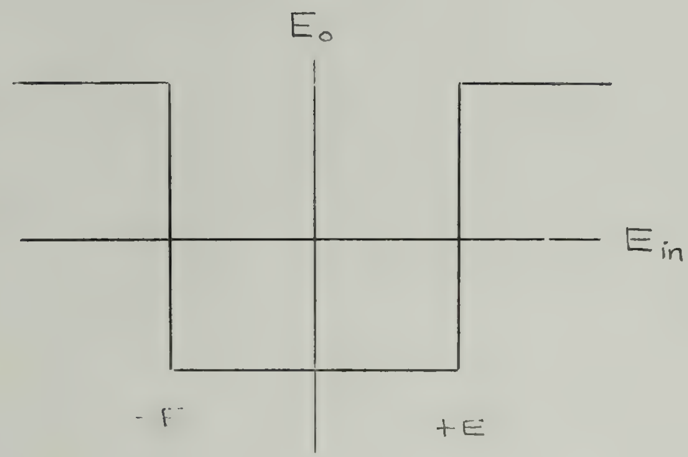


Figure 1. READ Circuit Transfer Function

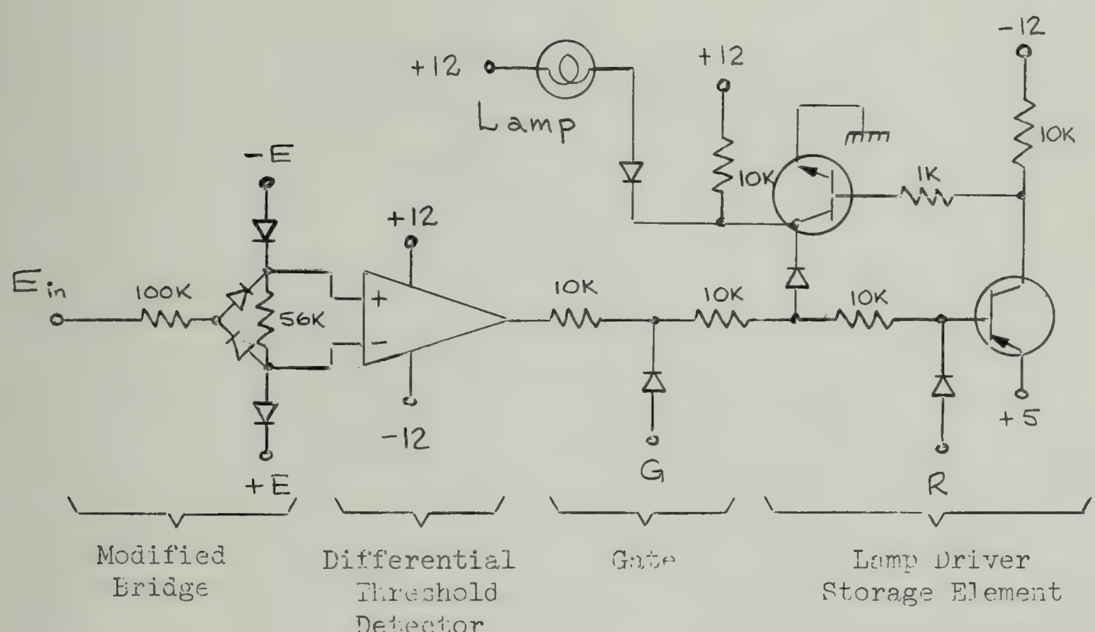
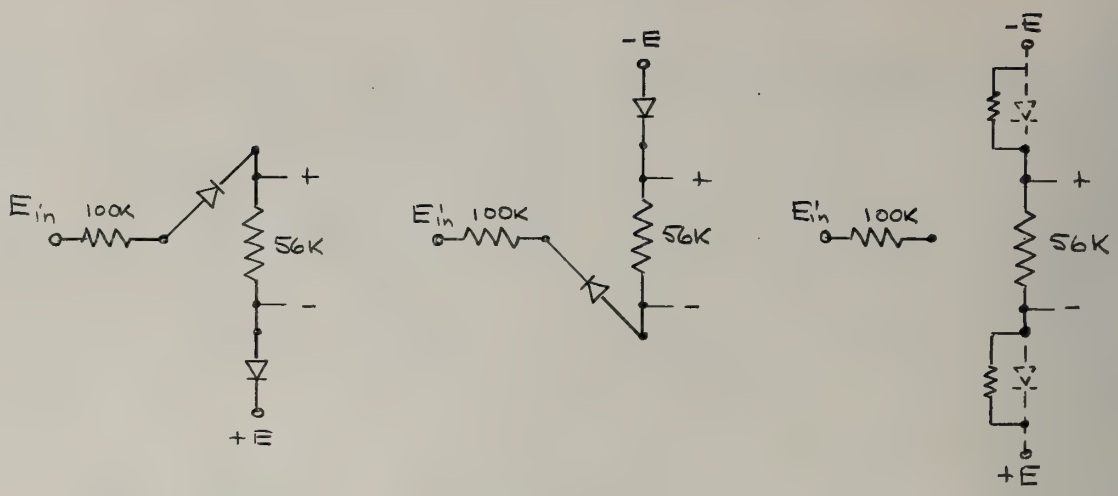


Figure 2. READ Circuit



$E_{in} > +E$ $E_{in} < -E$ $+E \geq E_{in} \geq -E$

Figure 3. Modified Bridge

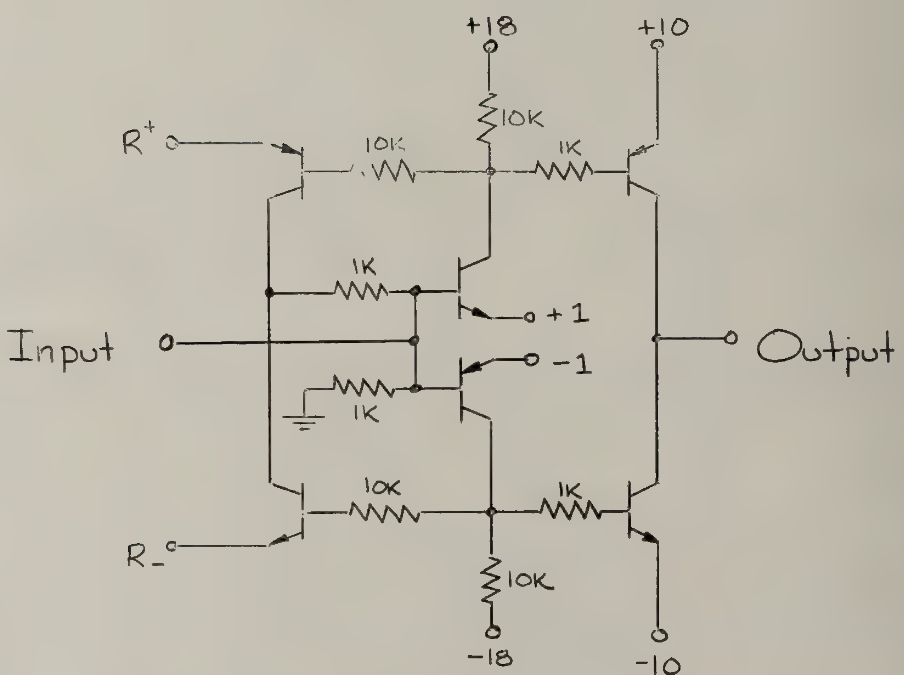


Figure 4. WRITE Circuit

1.4 Large Screen Television Display System (Project No. 09)

1.4.1 Introduction

Work was begun during this quarter on a system of large screen display with particular emphasis on displaying television signals. As envisioned, the system will be capable of receiving standard television signals and then projecting the final picture onto a screen, for example, a theater screen. The system will consist of four major sections:

1. Standard television receiving circuitry,
2. Store and scan unit,
3. Light beam deflection system,
4. Light source and intensity modulating device.

It is desirable that the system be capable of projecting black-and-white pictures. Later investigation might lead to a color projection system.

1.4.2 Television Receiving Circuitry

This part of the system will not be difficult to obtain. If necessary, the circuitry from a small portable television set can be used.

1.4.3 Store and Scan Unit

Internal synchronization, rather than synchronization to the pulses received in the television signal, would eliminate many difficulties in deflecting and projecting the light beam. The store and scan unit will store one frame of information from the receiver circuit and then present this frame to the beam modulation and deflection sections. The storage portion will be synchronized to the received television signals, and the scanning portion will be synchronized to the deflection system.

1.4.4 Light Beam Deflection System

The deflection of the modulated light beam will be accomplished by two systems of rotating or vibrating mirrors, one to provide the vertical deflection and the other to provide the horizontal deflection. Except for the high rotation rate needed for horizontal scanning, mirror deflection appears to be the easiest and least costly method of deflecting a light beam.

1.4.5 Light Source and Intensity Modulating Device

The choice of a light source will depend upon the method of modulation used. It might be necessary to resort to a laser beam if white light modulation does not prove practical. A library search was conducted to determine the various methods of modulating a light beam. The method which seems most attractive uses an ultrasonic transducer cell to modulate the light beam by Bragg diffraction. The amplitude of an ultrasonic carrier wave in the cell is proportional to the amount of light which is diffracted into the first order position of the diffraction pattern.

Robert Wickersheim

2. HARDWARE SYSTEMS RESEARCH

(Supported in part by the Atomic Energy Commission under Contract No. AT(11-1)-1469, W. J. Poppelbaum, Principal Investigator.)

Summary

David Casasent and Doug Sand report on the status of OLFT just prior to receiving the Pockels chamber system. David Rollenhagen's project is now known as VISTA (Variably Interlaced Scanning for Television Applications); he describes a pair of circuits that this will employ. In the Functional Encoding project Pete Oberbeck and Art Simons describe checkout of the Transmitter. The Tricolor Cartograph is nearing completion in the hands of Bill Kubitz. Orin Marvel has joined the group and, with Larry Ryan, is working on a new project to be called Transformatrix.

M. Faiman

2.1 On-Line Fourier Transform System (Project No. 12)

2.1.1 In-House Equipment

The electo-optic beam shutter, mentioned in an earlier report, was subjected to a series of tests of its electrical and optical operating characteristics, and was found wanting. It has been returned to the manufacturer for repair. Some of these tests were greatly facilitated by a newly acquired photometric microscope assembly, which will later be used to evaluate the optical performance of the system as a whole.

2.1.2 Pockels Chamber

The Pockels chamber is over 95% completed. The system consists of two racks of supplies for the write and erase electron guns and the vacuum system, the chamber itself, and a small rack containing the video amplifiers and the deflection drivers. The small rack must be placed close to the tube itself since the lead lengths must be kept at a minimum. This rack will be placed either on the table top or on a separate stand depending upon the vibrational effects of the whisper fans it contains.

Figure 1 is a schematic showing the various supplies and their interconnections. Most of the figure is self-explanatory. The isolation transformers are necessary since the anode of the electron gun is actually the crystal back which must be kept near ground potential. The flood gun supply is much simpler than that of the write gun since it emits a defocused spray of electrons. The erase-gun current control and acceleration potential are not shown; various configurations are being considered and future investigations will determine which is best. The focus supply is connected in series with the high voltage cathode supply to save the cost of a second high voltage source.

The write gun beam current is indicated on a meter connected to the high voltage isolation amplifier which applies the video signal input to the grid of the electron gun to properly modulate the electron beam.

A much more detailed performance report on the chamber will appear in a subsequent report.

Doug Sand,
David Casasent

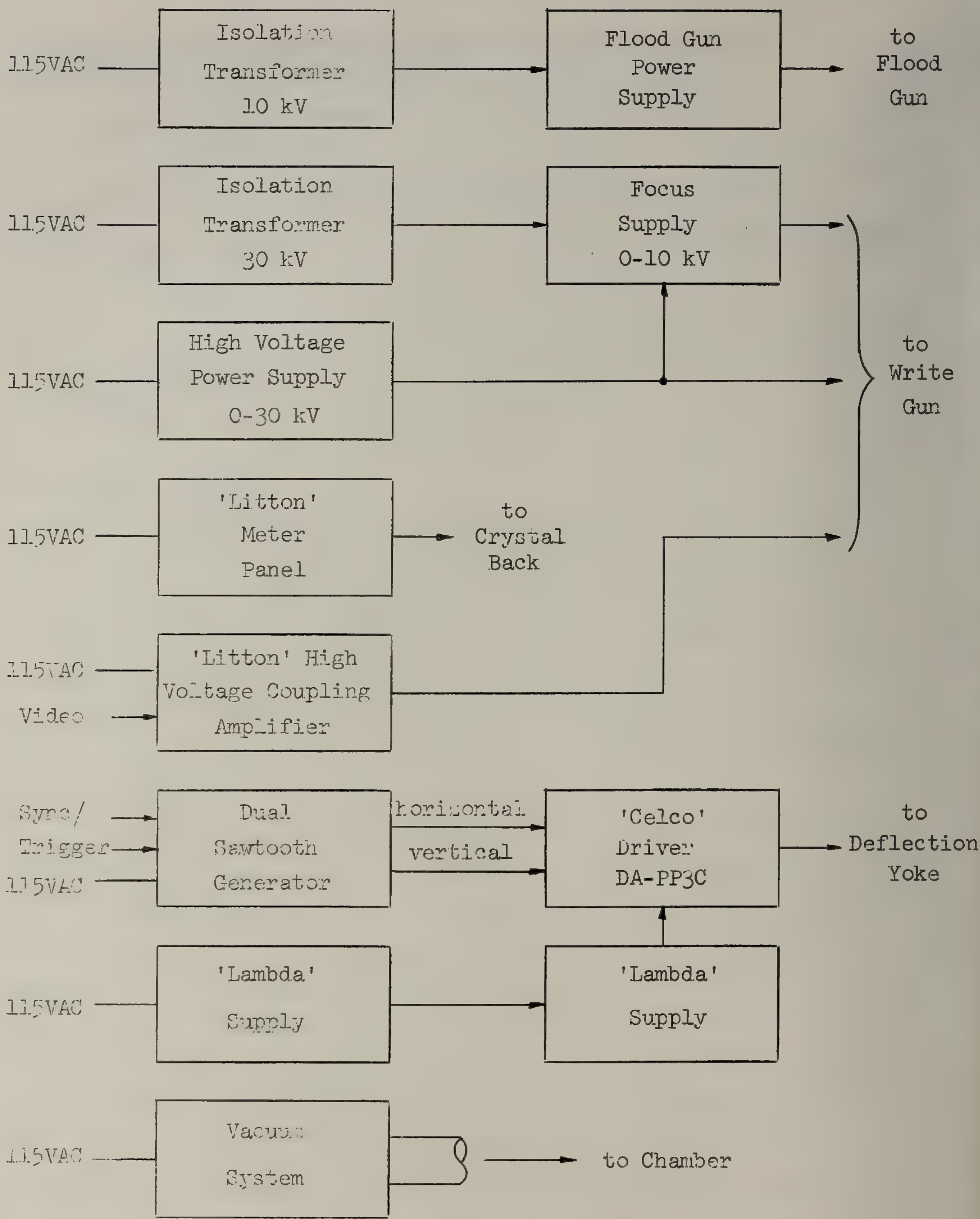


Figure 1. Pockels Tube Schematic

2.2 VISTA (Project No. 14)

2.2.1 General

This report describes an analog-to-digital converter which was recently developed, and an analog gate which was completed about a year ago, the details of which were never published.

2.2.2 A/D Converter

A 6-Bit A/D Converter was designed specifically for use in the VISTA system, although the circuit could easily be modified for more general use where higher speeds and a capacity greater than six bits might be required.

The conversion is initiated by the trigger input shown in Figure 1. The ring counter sets each flipflop of the register to "1" consecutively, beginning with the most significant input to the ladder network. The resulting output from the D/A converter is compared with the analog input. If the analog input exceeds the D/A converter output, the most significant input to the ladder network is maintained at "1", otherwise it is set to "0".

The ring counter next sets the second most significant bit to "1", and a second comparison is made. Comparisons are made in a like manner, proceeding to the least significant bit. At the conclusion of the six comparisons, the six inputs to the ladder networks are set such that the output of the D/A converter matches the analog input to within a small error. This concludes the analog-to-digital conversion until a trigger pulse again initiates the cycle.

The combinational circuitry shown in Figure 1 between the ring counter and the register insures that each flipflop of the register is set to "1" consecutively, and that the state of each flipflop changes only during the respective comparison and remains fixed at all other times. Omitted from the figure are miscellaneous buffers, the combinational circuitry which presets the ring counter

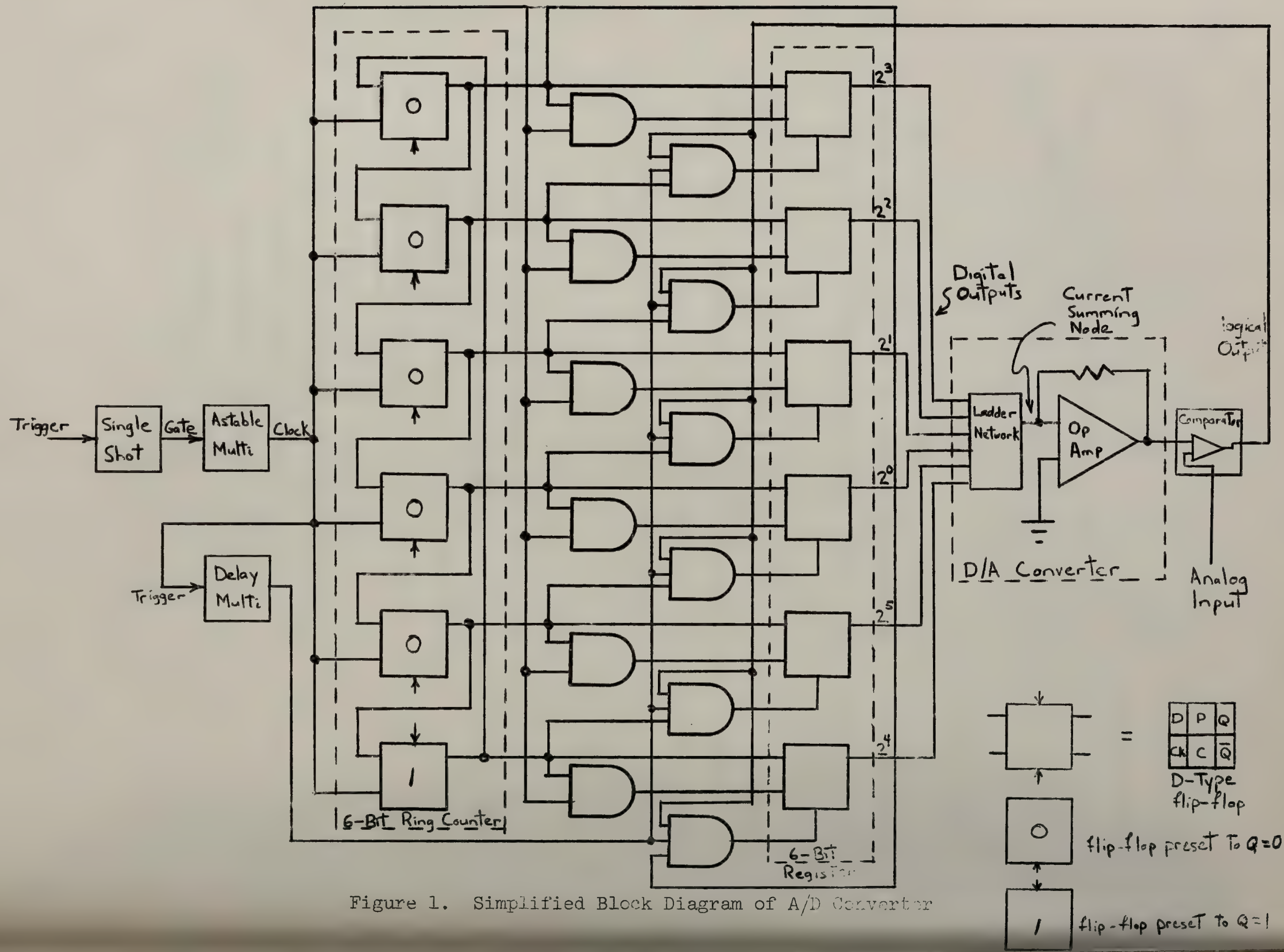


Figure 1. Simplified Block Diagram of A/D Converter

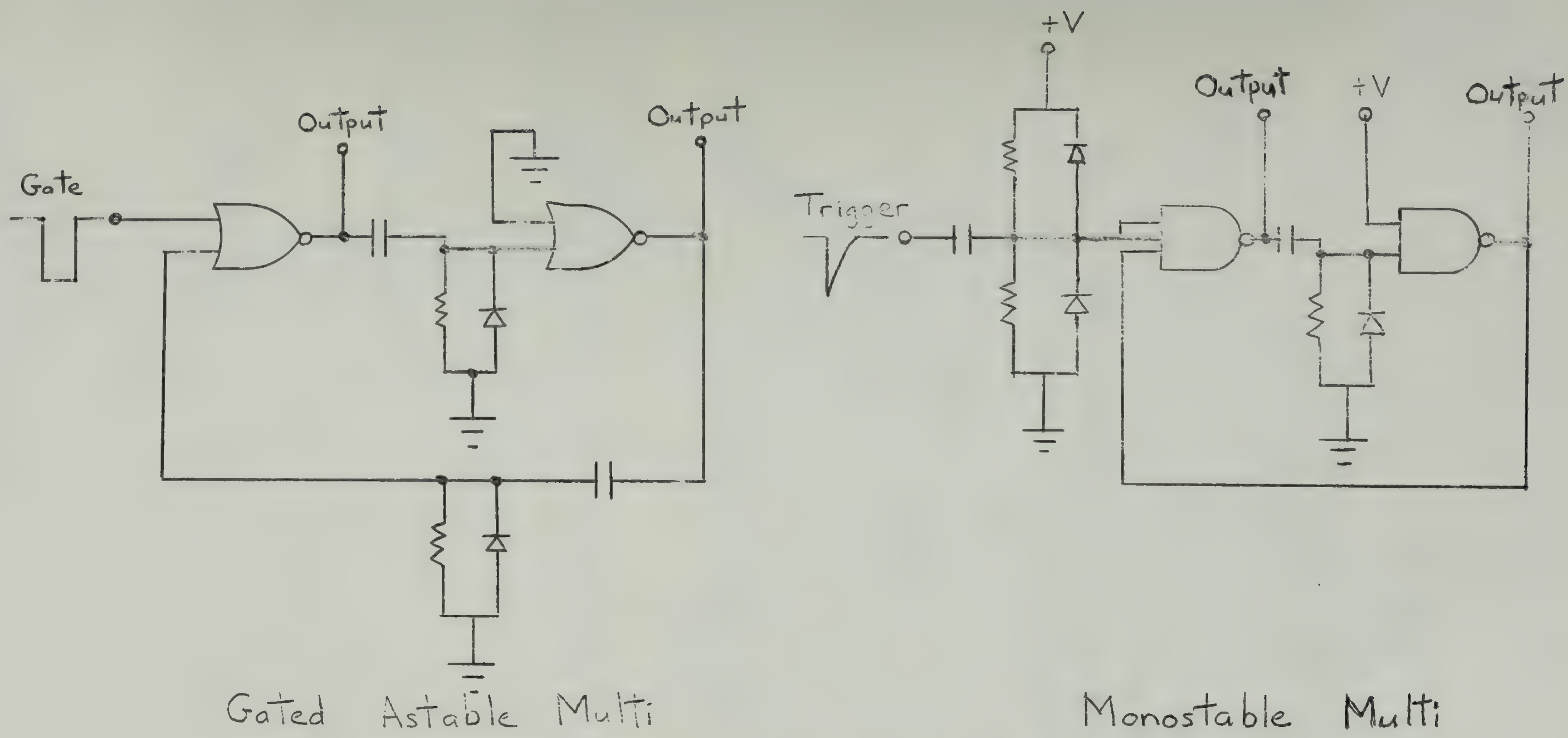


Figure 2. Multivibrator Configurations Used in A/D Converter

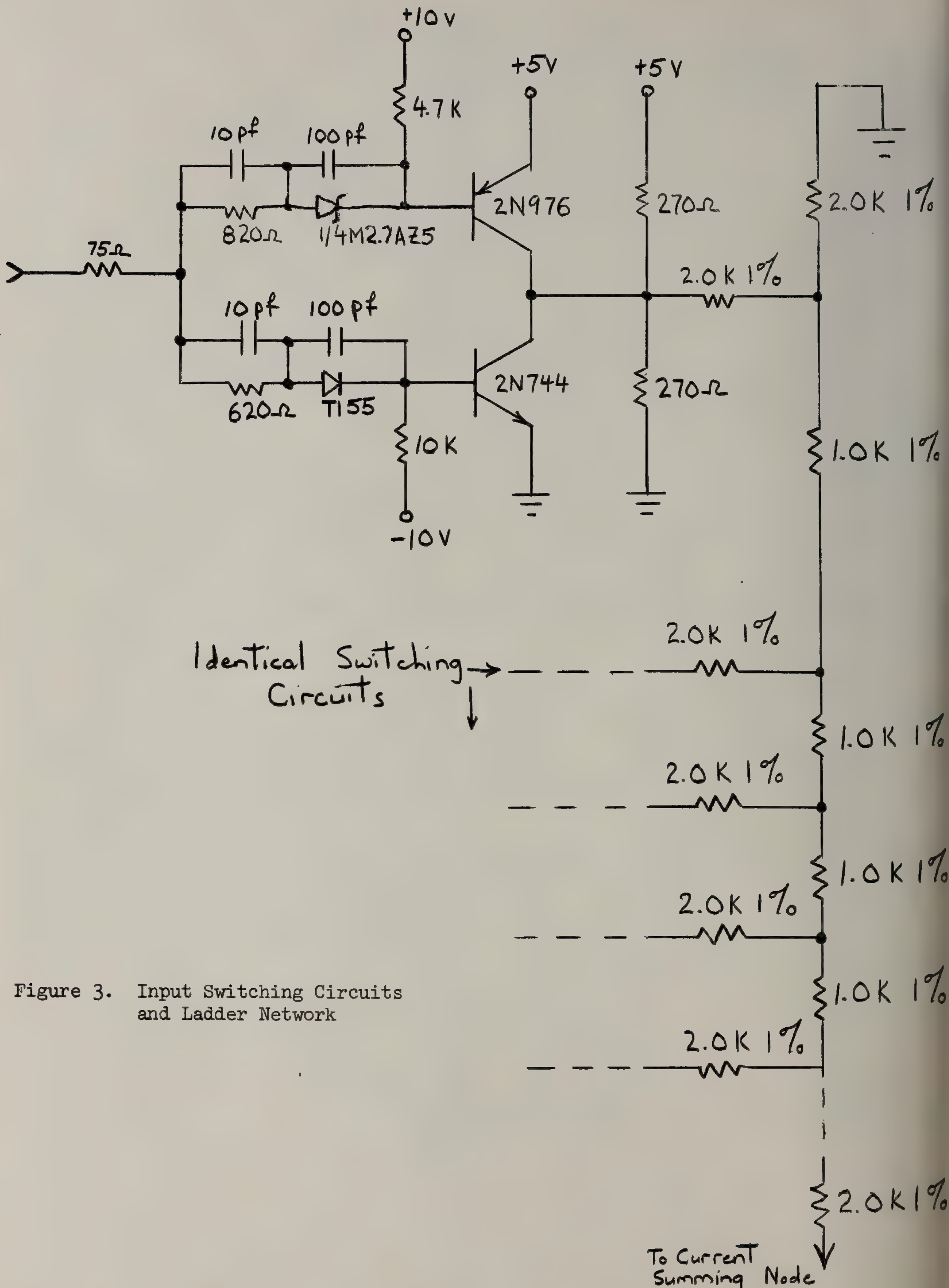


Figure 3. Input Switching Circuits and Ladder Network

to the states indicated, and the combinational circuitry which clears the register.

The single-shot gates the astable multi for six complete clock periods during which time the comparisons are made. The delay multi provides a settling time for the D/A converter and comparator before setting each flipflop of the register.

A complete conversion requires 5μsec, and may be initiated every 5μsec or slower. Although speed was not a crucial factor for its use in the VISTA system, it is estimated that the A/D converter could be made to operate at least ten times faster.

Figure 2 shows the multivibrator configurations which were found quite adequate for the A/D converter. All digital integrated circuits were taken from the SN7400N or SN7400HN series. The operational amplifier module is a Burr-Brown model 1510/25, and the comparator is a Fairchild μA701C integrated circuit.

Figure 3 shows the ladder network and the switching circuit between each flipflop of the register and the corresponding input to the network.

2.2.3 Analog Gate

An analog gate was developed for general use featuring high speed switching, 200 mw dc driving power and a floating output when the signal is blocked. In addition, the gate input may be driven directly by integrated circuits and requires very little driving power. Two complete gates are contained on each board, and four integrated circuit inverters are provided per board for inverting the gate input if desired. Normally, a logical "1" blocks the signal.

Figure 4 shows the circuit. The small collector resistors of the switching transistors account for the rather high power required of the -10 and +10 volt supplies. These resistors were chosen as small as was practical to enhance the switching speed of the gate. The first complementary emitter follower stage reduces

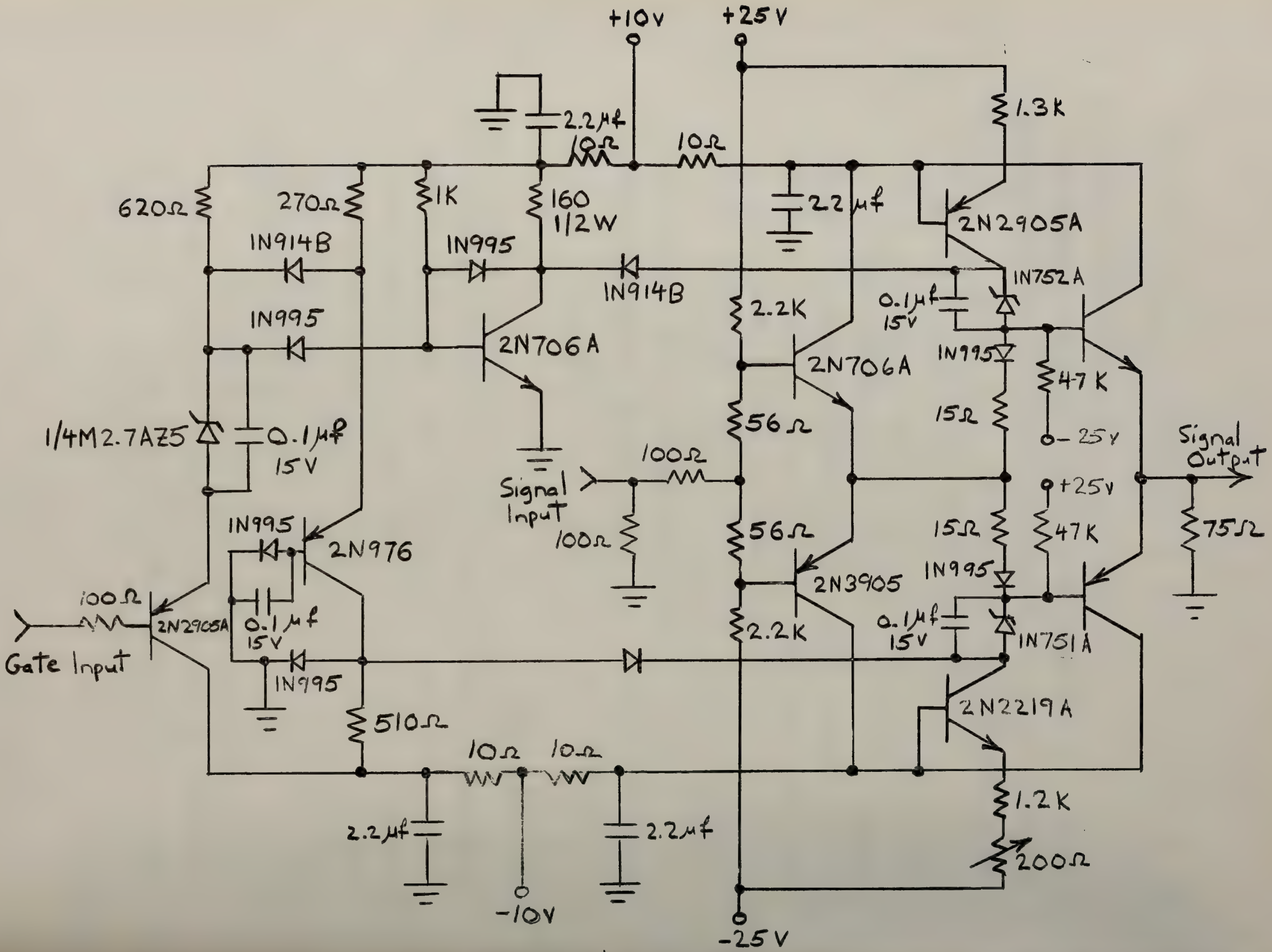


Figure 4. Analog Gate

switching transients at the output, while the second such stage provides driving power for the load. The emitter-base diodes of the latter form two legs of a diamond configuration, the other two legs being the IN995 diodes in series with the 15 ohm resistors. Two constant current sources provide a nearly constant voltage across the diamond for maximum linearity of the transfer characteristic.

The specifications of the analog gate which are self-explanatory are listed as follows:

2.2.4 Specifications for the Analog Gate

1. Maximum input signal: $\pm$ 5 volts
2. Gate voltage requirements:
   a. Gate voltage required to block a signal ("1" state): -3 volts maximum
   b. Gate voltage required to pass a signal ("0" state): -4.4 volts minimum
3. Current requirements (maximum) per circuit
   a. "0" state
      +10 volt supply: 61 ma plus load current (positive)
      -10 volt supply: 65 ma plus load current (negative)
      +25 volt supply: 24.6 ma
      -25 volt supply: 24.6 ma
      Gate input: 0.30 ma
   b. "1" state
      +10 volt supply: 105 ma
      -10 volt supply: 36 ma
      +25 volt supply: 24.6 ma
      -25 volt supply: 24.6 ma
      Gate input: 0.07 ma
4. Total heat power dissipated:
   a. In "0" state: 2.38 watts plus power delivered to load if termination is on board.
   b. In "1" state: 2.53 watts.

Measurements

dc transfer characteristics (gate in "0" state)

Input (v)	Output (v)	Input (v)	Output (v)
5.0	3.92	-0.05	-0.0179
4.5	3.82	-0.10	-0.0426
4.0	3.48	-0.2	-0.112
3.5	3.04	-0.3	-0.185
3.0	2.60	-0.4	-0.267
2.5	2.15	-0.5	-0.353
2.0	1.70	-1.0	-0.08
1.5	1.24	-1.5	-1.24
1.0	0.08	-2.0	-1.76
0.5	0.347	-2.5	-2.15
0.4	0.262	-3.0	-2.60
0.3	0.180	-3.5	-3.02
0.2	0.100	-4.0	-3.50
0.1	0.036	-4.5	-3.90
0.05	0.013	-5.0	-4.10
0.00	-0.0017		

2.3 Functional Encoding (Project No. 15)

2.3.1 Transmitter

Construction of the Transmitter is now complete and checkout has begun. As a first step, to facilitate the testing of logic functions and encoded video levels, a static, simulated video signal was used rather than a conventional one from a camera. Harmonics of the line sync signal were used to generate a vertical bar pattern with any of 4, 8, 16, or 32 elements, the number remaining the same from one line to the next.

By and large the system is performing as planned, although it has been necessary to take steps to reduce noise in certain sections. Testing with real video signals will begin shortly, and work is also starting on construction of the Receiver.

2.3.2 D/A Converter

Testing the configuration described in the last report has been delayed owing to late delivery of equipment. The most significant five bits of the converter are, however, now working, although this necessitated redesigning the logic level shifter to the configuration of Figure 1.

Peter Oberbeck
Art Simons

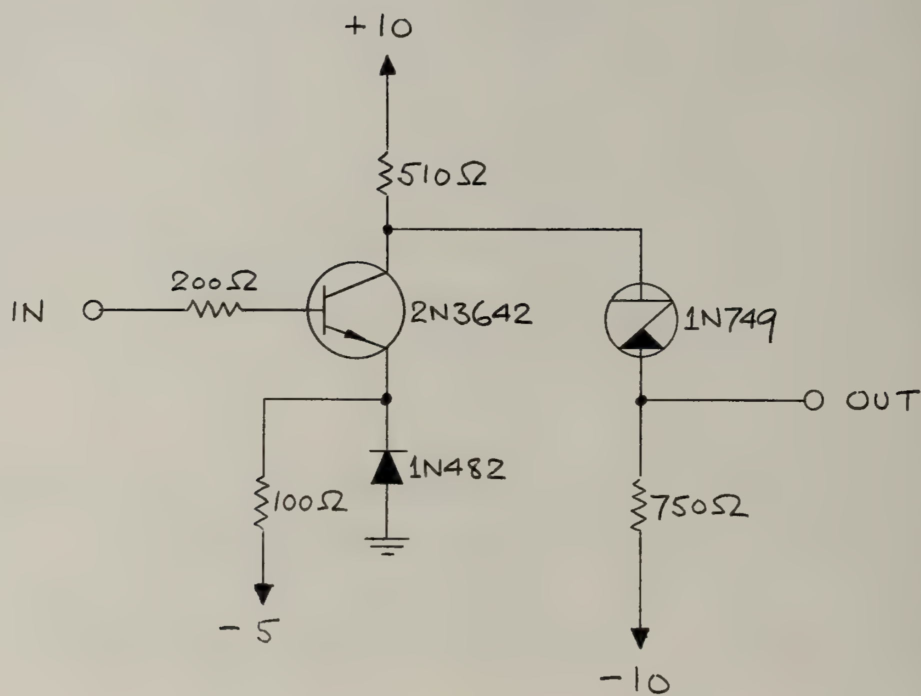


Figure 1. Logic Level Shifter

2.4 The Tricolor Cartograph (Project No. 16)

2.4.1 System Checkout

The system is now complete with the exception of one circuit which is expected early in January 1968. The disc recorder was received in November 1967 and appears to perform as anticipated. The checkout and debugging of the system have begun and at this point everything appears to be working. There have been no major changes in concept to date.

One problem which has manifested itself concerns the sensitivity of the light pen. The pen sensitivity is such that a rather high gray level background is required on the display. This is undesirable since it leads to insipid colors. To improve this situation, it will be necessary to make the pen more sensitive. At this time, it is uncertain how this will be done.

Hopefully, the next quarter will see the system become operational.

W. J. Kubitz

2.5 Transformatrix

2.5.1 Preliminary Noise Measurements

As a prelude to transformatrix different noise sources were studied. The three circuits of Figure 1 produced acceptable noise similar to that from a breakdown diode (Figure 2).

For the first time noise pulses were observed and photographed on an oscilloscope. This was done by storing a single sweep on a Techtronix 544 storage scope and then photographing the stored sweep. During this process, it was found that any type of capacitive load will adversely affect the random pulse signals.

Figure 3 was taken while the average frequency counter was connected. By comparing this with Figure 4, it is seen that the capacitive input of the counter has distorted the noise signal, probably masking other noise pulses and giving an erroneous frequency reading.

A model of a 2 x 2 Transformatrix is being discussed and built.

Orin E. Marvel

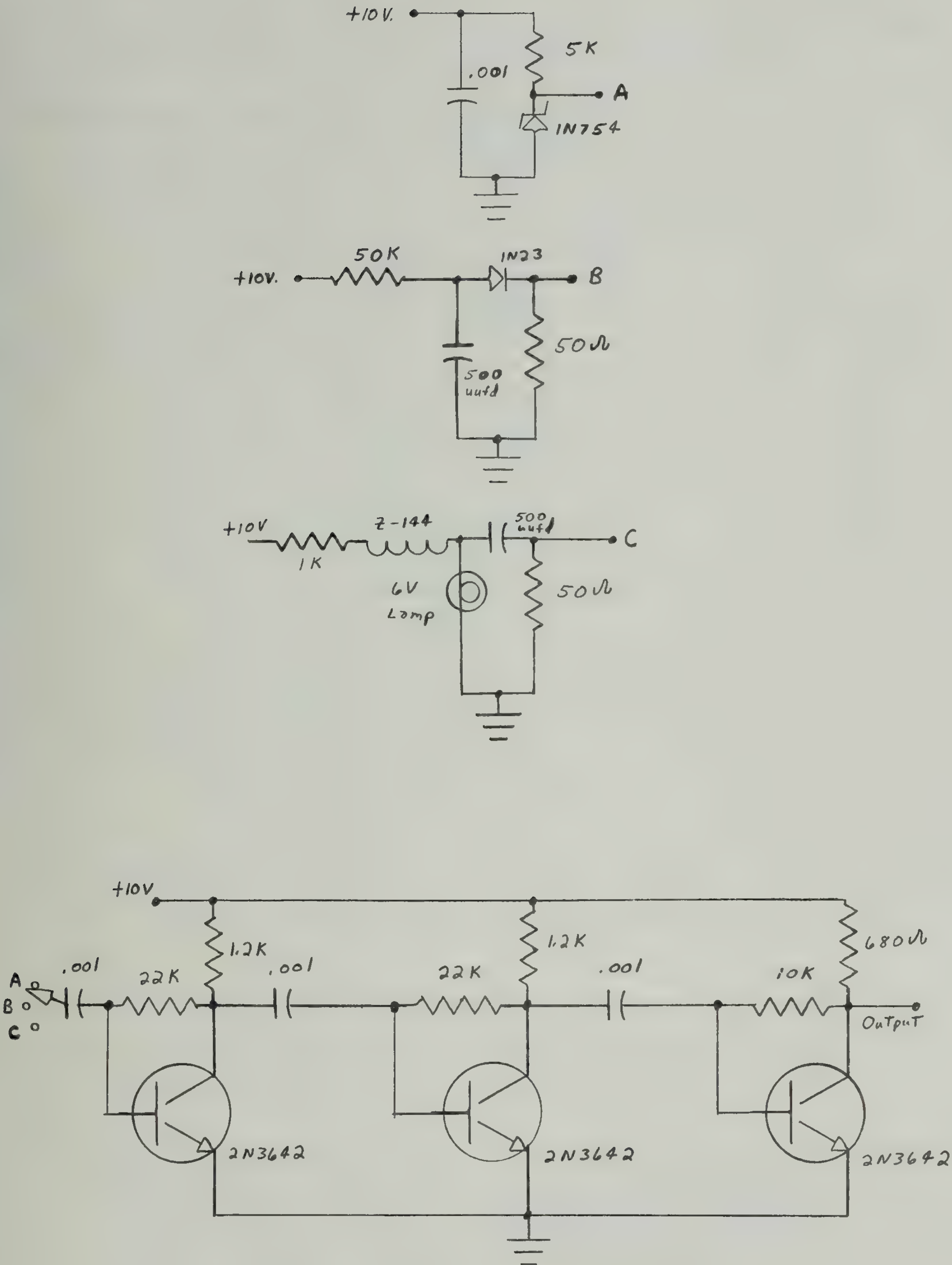
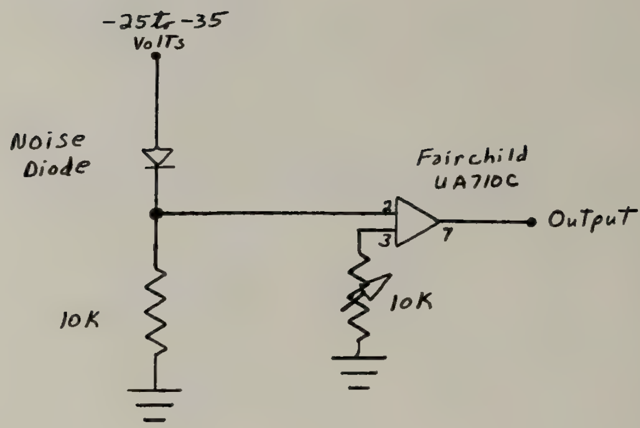
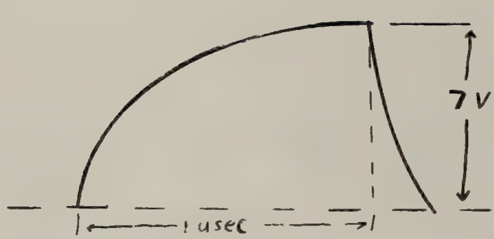


Figure 1. Three Types of Random Noise Generator

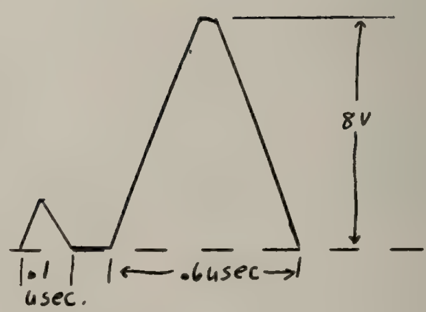


Plasma Diode Noise Generator

Figure 2.



Drawing from Photo of Frequency Counter Loading of Random Noise Generator.



Drawing from Photo without Frequency Counter in the Circuit.

Figure 3. Noise Pulses

3. SOFTWARE SYSTEMS RESEARCH PROGRAM

(This work is supported in part by Contract No. AT(11-1)-1469 of the Atomic Energy Commission and in part by the University of Illinois.)

3.1 Computer Aided Programming System - CAPS

3.1.1 The CAPS Software for the Programmed Buffered Display - Type 338

This quarter a new version of the flowchart drawing system on the 338 has been established as the current system.

This version contains a new light pen tracking procedure that significantly improves the speed with which a flowchart symbol may be moved across the Cathode Ray Tube (CRT) with the light pen. The improvement is primarily due to an improved method of handling and generating the light pen interrupts.

The use of the light pen in the MOVE mode is enriched in this version of the system. In the MOVE mode, the facility for moving a symbol now exists in two ways. The older method is that of light penning a symbol and then moving the light pen, which causes the symbol to be moved, to the desired symbol position. In this way the symbol may be moved arbitrarily to any position on the screen. The new method allows the user to select a symbol and then light pen the horizontal or vertical border displayed on the CRT. The recognition of the light penning of a position on the horizontal (vertical) border causes the selected symbol to move horizontally (vertically) to the same vertical (horizontal) position as the light pen. This allows a symbol to be moved over screen distances with two references of the light pen to the displayed border rather than with the continuous movement of the symbol in the older manner.

The reason for this additional MOVE facility is one of user convenience. This MOVE facility allows symbols to be positioned very quickly when a user is constructing a new section to a flowchart or when a symbol is to be added to a flowchart.

A new feature of this version is the use of displayed light buttons as mode switches in the same way that the physical push buttons are used as mode switches. Each light button is a displayed word which is a mnemonic for the mode that the light button controls. Each mode may be turned ON or OFF by light penning the appropriate light button or by pushing the correct push button. Either action complements the previous ON-OFF state of the mode.

Thus if the MOVE mode is ON, then light penning the MOVE light button causes the MOVE mode to be turned OFF. Light penning a light button causes all other modes to be turned OFF. This is in contrast with pressing a push button which only complements the mode represented by that button.

The reason for the inclusion of light buttons into the system is primarily one of user convenience. With only the push buttons as mode switches, one of the users hands is required for holding the light pen and the other hand is required for manipulating the push buttons. This means that one hand has to be freed and moved to the teletype for the task of inputting text. This is not only an uncomfortable situation, it is also physically tiring to use the system in this form.

With the inclusion of the light buttons, there is no need to require that one hand be used to manipulate the push buttons. Now, one hand can hold the light pen, used for mode switching, symbol indication, and symbol manipulation, and the other hand can input text, all without any drastic or large scale hand movement.

The HORZ (Horizontal) and VERT (Vertical) modes are new for this system. These modes are used to align a set of symbols horizontally or vertically. In using these modes, after the HORZ or VERT mode is turned ON, the first thing that must be done is to select, with the light pen, a reference point. A reference point may be any flowchart symbol or a point on the displayed border of the CRT. After a reference point is selected, each flowchart symbol that is light penned is given the same horizontal or vertical, depending on the mode that is ON, coordinate as the reference point. In this way, selected symbols may be aligned horizontally or vertically. To align another set of symbols the mode switch must be turned OFF and then ON again. This allows a new reference point to be selected.

The use of directly viewed graphical output of flowchart information is enhanced in the current system in the sense that a particular symbol may be blinked at full display intensity, while all the other symbols in a flowchart are displayed at a reduced display intensity based upon information supplied from a remote source. Uses of this facility are to indicate which flowchart symbol is currently being executed in a flowchart program or to indicate the existence of an error or other noteworthy conditions in a flowchart.

Produced this quarter is a file (File 739 - A User's Description of the Computer Aided Programming System (CAPS) Programs on the DEC 338) that is a description of the complete existing 338 CAPS software capability.

3.1.2 Proposed Additions to the CAPS 338 Software

These are a set of proposed additions to the capability of the CAPS 338 software. These additions are listed approximately in order of increasing difficulty of implementation. These additions will be implemented in the future.

3.1.2.1 Flowchart Size

Currently in CAPS there is the restriction that a flowchart must have all of its non-ARROW symbols displayed on the CRT. As a result of this, all ARROW symbols must start, end, and stay on the CRT. Therefore, the size of a flowchart is limited to the size of the CRT. For some purposes, this is an uncomfortable limitation.

One way in which to increase the allowable size of a flowchart is to consider that there is available a 40" by 40" CAPS drawing board internal to the 338. This drawing board is viewable piecewise through the 10" by 10" CRT viewing port or window. The position of this window on the drawing board may be moved by the use of the suitable mode switches ↑, ↓, ←, and →, and/or the soon-to-be-installed joy stick. Each mode switch indicates the direction in which the CRT viewing window will be moved, when it is on. The joy stick, when enabled, can also cause the viewing window to be moved, in a manner analogous to the arrow mode switches.

With these mode switches available, we get the increased flowchart drawing capability in the following way: with a normal blank flowchart as a starting point, a portion of a flowchart may be constructed in the normal fashion. Then, for example, by turning ON the → mode switch we may change the position of the CRT viewing window in relation to the large flowchart drawing board. While the → mode switch is on, we observe that the constructed flowchart moves horizontally out of view of the CRT window to the left while blank flowchart drawing area comes into view from the right side of the CRT window. If the → mode switch is left on long enough the original flowchart will come back into view as a result of the implementation technique. Similar treatments of the CRT window are generated from the ↑, ↓, and ← mode

switches. As a result of the actions caused by any of these mode switches, the CRT window may be positioned over some blank space on the flowchart drawing board which can then be used for more flowchart construction.

In this scheme there is a modified version of the older restriction in that all of a flowchart's symbols must appear on the larger drawing board. This means, for example, that ARROW symbols may start from a symbol in the CRT window and go to a symbol outside the CRT window; or that only part of a symbol will be displayed on the CRT. These type of things give visual cues as to the location of parts of the flowchart that do not appear on the CRT window and do not detract from the display.

This scheme enlarges by a factor of 16 the amount of usable space that can be used for flowchart drawing. There are still restrictions on the size of a flowchart, but these new restrictions are substantially less binding than the older restrictions.

3.1.2.2 Viewing Scale

In the proposed scheme for increasing the allowable flowchart size, there is the problem of not being able to directly view more than 1/16 of the usable flowchart drawing area because of the large drawing area and small viewing window. This problem can be solved by associating with each flowchart a software scale factor, x1, x2, or x4, for use in viewing the flowchart. The scale factors x2 or x4 allow a selectable 1/4 or 1/16 of the entire flowchart drawing area to be viewed. The particular segment of the whole drawing that is to be viewed in scales x2 and x4 is determined by the relative position of the viewing window with respect to the whole drawing.

The restriction that scales x1 and x2 are only to be used for viewing the flowchart and that scale x4 is to be used for flowchart construction, edition, and viewing is required in order not to reduce the effectiveness of the existing system and to simplify the required implementation.

In scale x4, the indicated portion of the flowchart is displayed exactly as a flowchart is displayed in the current system. In scales x2 and x1 there will be no text displayed on any symbols and the size of the symbols will be reduced according to the scale indicated.

The viewing scale will be controlled by the new light button mode switches x1, x2, and x4. These light buttons will operate exactly like the other light buttons.

A more general scale factor feature that would allow an arbitrary scale factor to be input by the user with a joy stick or similar device and which would affect the view of the flowchart drawing is not considered to be worth the effort required to implement it. The three discrete scale settings offer the ability to see all of the flowchart or a particular portion of the flowchart in two levels of detail. The more general form would just be a more flexible way of doing the same thing.

3.1.2.3 Flowchart Symbol Grouping

In the course of using the existing system, there have been times when a user would like to treat a group of flowchart symbols as if it were one particular symbol. For example, the user might want to move three symbols to a new position on the flowchart and maintain the initial spatial relationships between them. What the user would like to do is to be able to move any one of the three symbols with the light pen and have the other two symbols be moved in parallel in exactly the same manner.

The current system provides for moving only one symbol at a time. Therefore to move the three symbols, they must be moved on at a time and this method of moving them destroys the initial spatial relationship between them.

As an answer to this question, the GROUP mode is proposed. This mode will allow one set of symbols to be designated as a group of symbols. Any action performed on one member of the group will result in related actions on all members of the group. In the above example, once the three symbols had been established as a group, then to move the three symbols as one symbol the user only needs to move one member of the group and the rest of the members of the group will be moved in parallel.

In addition, an entire group of symbols may be deleted by deleting one member of the group or all of the symbol types of the group may be changed by changing the symbol type of one member of the group. When one of the members of a group is aligned in the VERT or HORZ mode, then the entire group is MOVEd in order that the indicated symbol may be aligned and still maintain the spatial relationships between the members of the group.

When the GROUP mode is turned ON, then all evidence of previous group membership is destroyed. Each symbol light penned while in the GROUP mode indicates that this symbol is to be a member of the group. As each

symbol is light penned, the display of the symbol starts to blink as a visual cue that it is in the group. After the user has put all the desired symbols in the group, the GROUP mode is turned OFF. This also stops the blinking of the symbols that are members of the group.

With the addition of the GROUP mode, the user is given even more freedom in manipulating and using the flowcharts that he has drawn.

3.1.2.4 <u>Character String Searching in the Text of a Flowchart's Symbols</u>

There are occasions when the user, seated at the 338 console with a flowchart on the CRT display, would like to have identified for him every flowchart symbol that contains a particular character string in its associated textual information. For example, while examining a flowchart program, the user might like to find all the references to the variable name ABCDEFG in an effort to find out why and where the value of the variable is being overstored.

In the spirit of the above example, we propose that there be some method of typing in a character string, giving a command, and then being able to visually distinguish all the symbols containing matches with the input character string.

The implementation of this facility might take the form of requiring that an initial command character be typed, indicating the start of the input of a character string to be matched. Next the user would type the character string followed by a final command character indicating the temporary end of the character string. This would be the cue to blink all the symbols containing character string matches. There might be a continuation command character that could be typed that would allow the string for matching to be edited in some fashion. This would allow a user to see where substrings of the original string are located or where more complicated strings are located.

It is felt that these proposed additions would be useful and valuable additions to the CAPS 338 software capability.

3.1.3 Facility for Writing Flowchart Programs Within the Framework of Existing Programming Languages

This facility is in the form of a program that will run on the DEC 338 and will take an existing flowchart drawn on the DEC 338 and make up a set of BCD card images from the flowchart. These BCD card images correspond to lines of text inside each flowchart symbol on the flowchart. Language labels are generated by the DEC 338 to handle control flow transfer.

The idea behind this program is that one can draw flowchart programs on the 338 and in the flowchart symbols make computer program statements in the desired computer programming language (FORTRAN, ALGOL, PAL, NICAP, PL/1). The lines of text within a given flowchart symbol will be converted into card images and then will be available for transmission to the ILLIAC II or to the S/360 via the PDP-7. Also flowchart programs written in PAL (the PDP-8 assembly language) can be assembled on the PDP-8 from DECTAPE (local PDP-8 magnetic tape). Thus one would have a very convenient and useful system in that he could plan and program in terms of flowcharts and also code a flowchart program in existing programming languages.

Design specifics have been discussed for this program and a flowchart representing the program has been drawn. Implementation on this program is now well under way with several basic subroutines coded and debugged.

3.1.4 The CAPS Software for the ILLIAC II

On November 6, 7, and 8, 1967, there were several demonstrations for the Computer Graphics Conference of the CAPS system running on the DEC 338 and the ILLIAC II. As of those dates, we demonstrated the following capabilities with CAPS:

1. The ability to draw and edit flowcharts using the DEC 338.
2. The ability to store flowcharts on and later retrieve flowcharts from DECTAPE on a name basis.
3. The ability to send flowcharts drawn at the 338 to the ILLIAC II.
4. A hard copy (CalComp Plotter) version of the flowchart may be produced via ILLIAC II.
5. If the flowchart is written in the CAPS language, then the flowchart may be executed on the ILLIAC II.

6. As the flowchart is executed in the ILLIAC II, the path of the execution may be indicated on the flowchart displayed on the DEC 338.

7. At any time during the execution of the flowchart, the execution may be stopped and the value of any variable displayed and also system parameters examined. (For example, where are we currently executing, how many times have we recursively entered this subroutine, etc.)

Using CAPS we are able to show flowchart programs that have been drawn (or written), debugged and now execute properly. One of these flowchart programs is a flowchart to calculate the square root of a number; another flowchart program calculates the factorial of a number. And still another flowchart does the integration of a provided function represented by a flowchart. The latter two routines are recursive.

After this demonstration, an evaluation of the ILLIAC II portion of CAPS was completed. As a result of this evaluation it is apparent that there are two possible paths open for pursuing CAPS.

One alternative is to complete the current version of CAPS. This entails adding additional primitives that are required for completeness of the system. The other alternative is to start from "scratch" on a new, vastly improved CAPS II. CAPS II would differ from CAPS I in language definition and implementation specifics. Both of these options have been examined in detail. Descriptions of both languages and a discussion of the differences between the two have been written. These will appear in a report, to be published. The decision, based upon these studies, is to proceed with CAPS II.

This report is based upon work complete, in process, and planned by T. Y. Lo, F. K. Richardson, and S. Wilkins.

T.-Y. Lo
F. K. Richardson
S. Wilkins

3.2 ILLIAC II Time Sharing

Software design for ILLIAC II time sharing is now completed; the following is a short description of the operating system. This system is based on BOOTS II, its predecessor, and only major differences will be discussed.

The system supervisor is divided into three parts: an in-core monitor which handles all input-output operations and interrupt servicing, conditionally resident file accessing routine to handle buffered input-output to user's files, and a non-resident scheduler to determine the sequence of operations and all priority levels for specific tasks.

The second routine (for accessing user files) is included with the in-core monitor for programs which are not deemed sufficiently reliable to have direct access to the filing portion of the disk. This portion contains all user programs, compiler-built object code and listings. Currently the filing routine is required for user programs (those typed in by the user at one of the various terminals), the Fortran compiler, and the two-pass binary loader.

All system protection is performed by this routine and the in-core monitor. The operation differs, however, from previous systems in that only the monitor is allowed to function in interrupt disabled mode (ID mode). When a file record is requested by an executing program, the monitor disables core protection for the file accessing routine, but still requires that all input-output operations be done through the monitor.

The non-resident supervisor maintains information on the activities of all sixteen consoles. From the standpoint of the supervisor a user is either logged out or currently running a program, using the command processor, or using Tipsy.

Tipsy (programmable numerical calculations routine adapted from the previous system) and the command processor, which corresponds to BOOTS, are both given system status, operate re-entrantly, and when inactive are always in a state of waiting for input-output completion on the associated terminal.

The command processor recognizes all requests to run user programs and perform Fortran compilations. The requests are translated to determine the track address of core loads on the disk, and the request is passed on to the supervisor in this form. The supervisor copies the core load from disk to

drum in order to be able to bring in and remove a given core load as rapidly as possible. Differing from previous systems, the utilization of the drum is such that it is possible to retain executing core loads for all sixteen consoles on the drum simultaneously, rather than only one. Drum allocation is dynamic, and a user is given only as much space on the drum as is requested. This means that only part of core will be saved in the event that his program is temporarily removed from execution. In a Fortran program, however, the user need not be concerned with this, as the compiler makes the correct request automatically.

Executing core loads are not given status, which effectively means they may not indiscriminately access all portions of the disk, and are not allowed any access to the drum or tape drives. In addition they receive low priority, so that they are allowed to run only when the command processor and/or Tipsy is in the wait state for all consoles linked to them. Executing programs which frequently do I/O to the terminal are given greater priority than those which are performing pure calculations.

The command processor is the direct link between the user and the system. It allows the modification and utilization of all user programs in their source form (card images). As stated before, the command processor is also responsible for retaining the compiler produced object code and listings. As in previous systems, all lines of the source program are identified by line number; the basic command structure allows the user to add, delete, modify, or list card images of a given program on the basis of these line numbers. The system ensures that the source program is kept sorted on this basis.

The filing structure is similar, but not identical with the BOOTS II system. A master ID table contains a list of legal user code-names, and corresponding pointers to their file dictionaries. Normally, a user may access only files in his dictionary, but facilities are provided for copying files belonging to other users. The dictionary makes a sharp distinction between source card images, object code, etc., held under a given file name, providing rapid access to the portion required.

Primary advantages of the current system are its reliability. Nearly 100% of system failings are hardware oriented, and are usually correctly recovered by the software. The main restrictions of the user at this point are probably limited ability to access files from a running program, and the

insufficient variety of compilers available: Fortran II only. Console response time is quite reasonable: with eight users (half load), average time of response is approximately one second.

A. Whaley

3.3 PLORTS Terminal System

Work on the 360 PL/One Remote Terminal Subset has concentrated largely on the syntax scan (Pass 1) of the system. The filing system and the Phase 0 (remote job entry only) time-sharing monitor have been outlined in rudimentary form; the former is briefly described below.

The three passes of the interactive PLORTS compiler/executor have been fairly well defined and differentiated; there still exist a few functions which have not been irrevocably assigned to a particular pass. In essence, Pass 1 is a line-by-line (necessarily incomplete) syntax analyzer and partial translator (e.g., conversion of infix arithmetic expressions to suffix strings), and allows a program file to be constructed one (syntactically correct) line at a time. Pass 2 performs the more sophisticated syntax analysis (particularly interstatement relationships) and the compilation from intermediate notation as output by Pass 1 into a form suitable for Pass 3, the interpretive executor.

A number of macro-instructions have been written by the group and have found their way into Pass 1 and related debugging routines; these are enumerated and described below.

The PLORTS system is designed to operate in one partition of our 360/50 using MFT, with the ASP operating system occupying the higher-priority partition. The nature of this beast gives rise to at least two families of problems. First, there is at present no reasonable way to predict the availability of processing time to PLORTS, since ASP usurps control of the system at will. Second, we will need ways to pass data and processing control from one partition to the other.

In connexion with the former, the PLORTS group is writing and debugging some modifications to the ASP system to accumulate statistics on resource requirements and usage. None of these are presently in the working ASP system; a timekeeping routine, however, seems to be working properly and will be added to the system shortly. This routine measures the total amount

of time ASP spends in run state and in wait state (the latter being the time that will be available to PLORTS), the number of times wait state is entered, and the maximum time the system spends in run state without waititing at any one time. When this routine is added to the system, the results should prove valuable in furnishing some sort of time parameters for design of the time-sharing monitor.

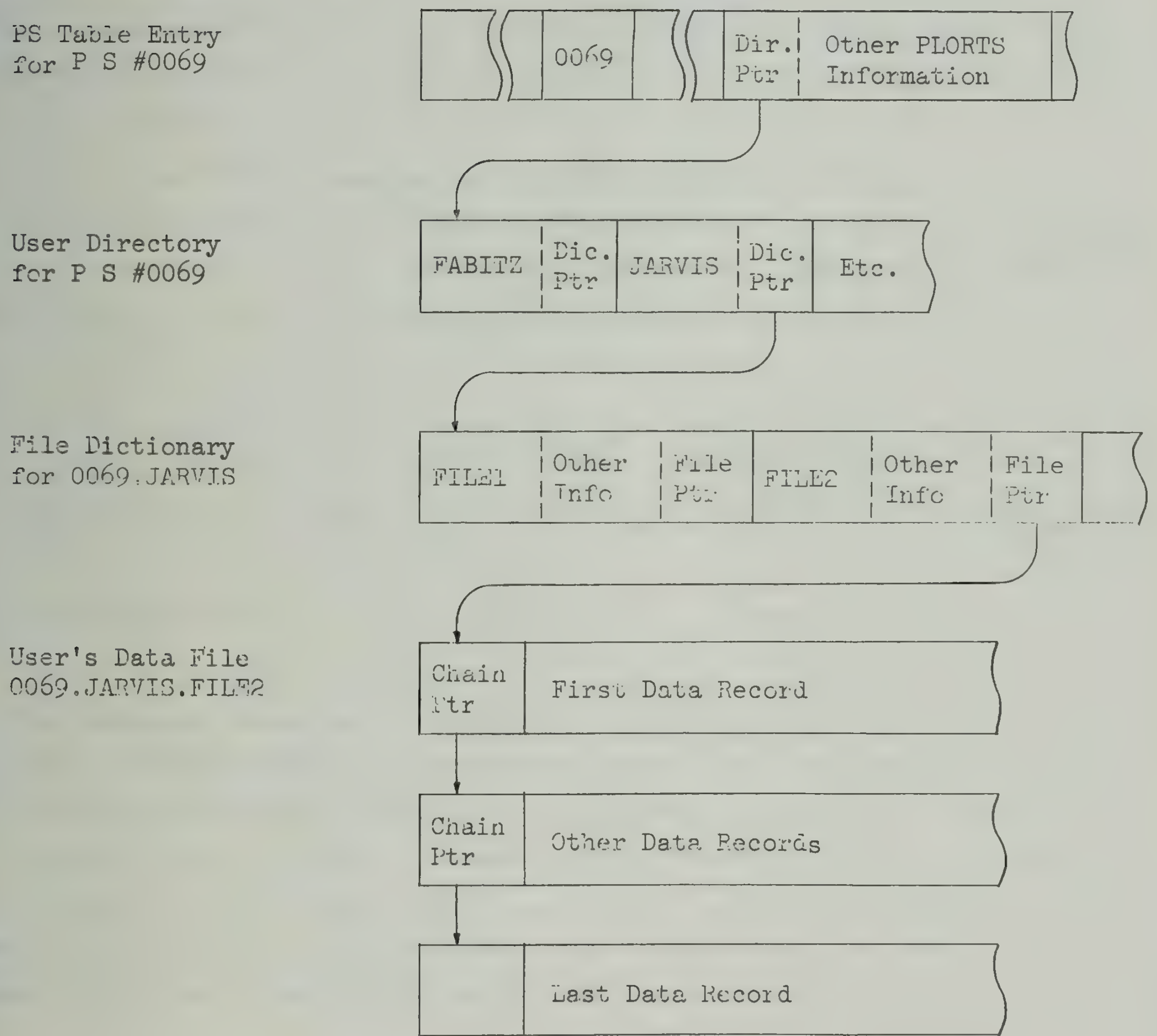
3.3.1 PLORTS Filing System

The current final preliminary design of the filing system is organized by Problem Spec Number; a three-word field has been reserved for PLORTS in each entry of the Problem Spec Table, and this field includes a track pointer for each PS number's user directory. This pointer is the top of a series of pointers to disk tracks; the end of the sequence is a particular file on the disk. At the time a user signs on at a terminal, he identifies himself by number and name. At this time, the monitor will use the directory pointer to find the directory for the PS number, and will obtain therefrom the track address of the user's File Dictionary. This address is saved in core until the user signs off.

The organization by PS number and user name means that uniqueness of file names need be maintained only for each individual user under each number; i.e., every user in the system could have a file called MADNESS. The directory hierarchy will logically treat each file as e.g. 0083.DAVIDSON. RIGHTEND, stooping to OS/360 notation. In this example, if Ben Davidson is signed on at a terminal, under PS #83, he may reference this file as RIGHTEND. Another user under the same number would have to call it DAVIDSON.RIGHTEND; an "outside" user, 0083.DAVIDSON.RIGHTEND.

Each entry in the user's File Dictionary will also include such data as file security information; a user may for example make one of his files available to other users on a read-only or execute-only basis. A simple-minded diagram of the directory system appears on the following page.

Example of Plorts File Directory Hierarchy



The P S number, user name, and user's File Dictionary address will be stored at signon time. If Howard Jarvis wants to access the file, he can call it FILE2. It must be referenced by another user who has signed on under P S #0069 as JARVIS.FILE2; by "outside" users as 0069.JARVIS.FILE2.

3.3.2 Macro Instructions

Since many changes have been made in the existing macros, there follows a report of Status to date.

The BRNCH macro, which is used to effect branches to entry points in external routines, has been changed so that the default Savearea is the one R13 points to.

The DYDMP macro, which takes snapshots of user routines and storage during execution, has been changed so that the default Savearea is the one R13 points to. Also the areas to be dynamically dumped are listed in Snaplis instead of within the macro so that they can be more easily changed.

A macro GBLCR has been added for the purpose of testing. Its function is to fetch the next blank character from the input stream, thus clearing the input stream in case of an error.

A macro STPRG has been added which defines the "main" program. This macro sets up the base registers, R9 for the main program, R10 for subroutine base registers, and R8 and R5 for the storage DSECT. It also opens the necessary data sets and clears the registers prior to execution of the main program. There is a secondary entry at the point where the registers are cleared for program loops.

NDPRG, the companion macro to STPRG, closes the data sets and defines an ABEND, register equivalences, and DCB's.

The SUBST macro, which starts subroutines by saving registers and defining the entry, has been completely rewritten. The user may now specify 1) whether or not he needs a Savearea, 2) if he needs a Savearea, whether he will supply one (or take the default) or whether a GETMAIN should be issued to get a Savearea (in order to make the subroutine recursive). If he specifies that he does not need a Savearea, a single fullword is used to store the pointer to the caller's Savearea (R13) so that the companion macro SBEND can function properly.

The SBEND macro has been rewritten to allow (upon exit from a subroutine) the options of:

1. passing a parameter or parameter list

2. passing a return code in R15

3. restoring R2 and R7 (output pointer register)

4. specifying the return address to be

   i) the link provided by entry to the subroutine,

   ii) in a register (other than R14) which has been generated during the execution of the routine or

   iii) an entry point address (not beginning with "R").

The RECØDE subroutine, which takes the eighty-EBCDIC-character card image from BUF1#2 and expands it to eighty halfword BS characters in BUFFER1, is now completely debugged. The routine passes no parameters and does not use a Savearea.

The GETCHR subroutine, which gets the next BS character from the input stream and puts it into R2, is also debugged. It passes no parameters, saves R2 and R7, and requires a Savearea (GETCHRSV). A companion routine to GETCHR has been written: GETNBLCR, which gets the next non-blank character.

3.3.3 The PLORTS Language

The PLORTS Language is a subset of PL/I, with restrictions and variations imposed by the relatively small scale of the PLORTS system and by the nature of remote terminals and interactive processing. Upward compatibility with full PL/I as implemented for the IBM System 360 has been retained as a design objective.

Identifiers in PLORTS are restricted to no more than six characters*. The following statements are not available in PLORTS: DELAY, DELETE, DISPLAY, LOCATE, ON, READ, REVERT, REWRITE, SIGNAL, UNLOCK, WAIT, WRITE, FORMAT. Structures and character strings have been omitted. Maximum number of dimensions for arrays is six. For the attributes which cannot be specified by the user, see the description of the DECLARE statement syntax scan. Precision is limited to single at present and should not be specified by the user. If statements may not be nested. Only list-directed input/output is available.

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* cf L. Pirandello

The PLORTS language is line-oriented; i.e., one and only one statement may be entered on each line. A problem arises, however, with the compound statement types allowed by the IF statement. It has been decided to treat the THEN and ELSE clauses as separate statement types.

3.3.4 The PLORTS Compiler/Executor

The PLORTS compiler/executor is interpretive, and is broken into three passes. The first pass is a line-by-line syntax scan, and produces an intermediate-language output to the second pass. Pass 1 output is described below in some detail. The second pass completes the syntactic checking, since the requirements involving DO closures, block closures, and compatibility of attributes for different uses of an identifier cannot be checked in the first pass, which checks each line individually as it is entered. This allows lines to be added or deleted by the user in the course of entering his program.

The output from the first pass is mixed reverse Polish; i.e., all arithmetic expressions as they are checked are output in Polish suffix notation. Statements other than arithmetic assignment generally produce information in tabular form in addition to the suffix notation of arithmetic expressions.

The second pass completes the syntax check, enters the table pointers for identifiers in place of the internal-form character string, and transfers the table information from the first pass output string into the symbol table.

The third pass is the actual interpretive execution pass.

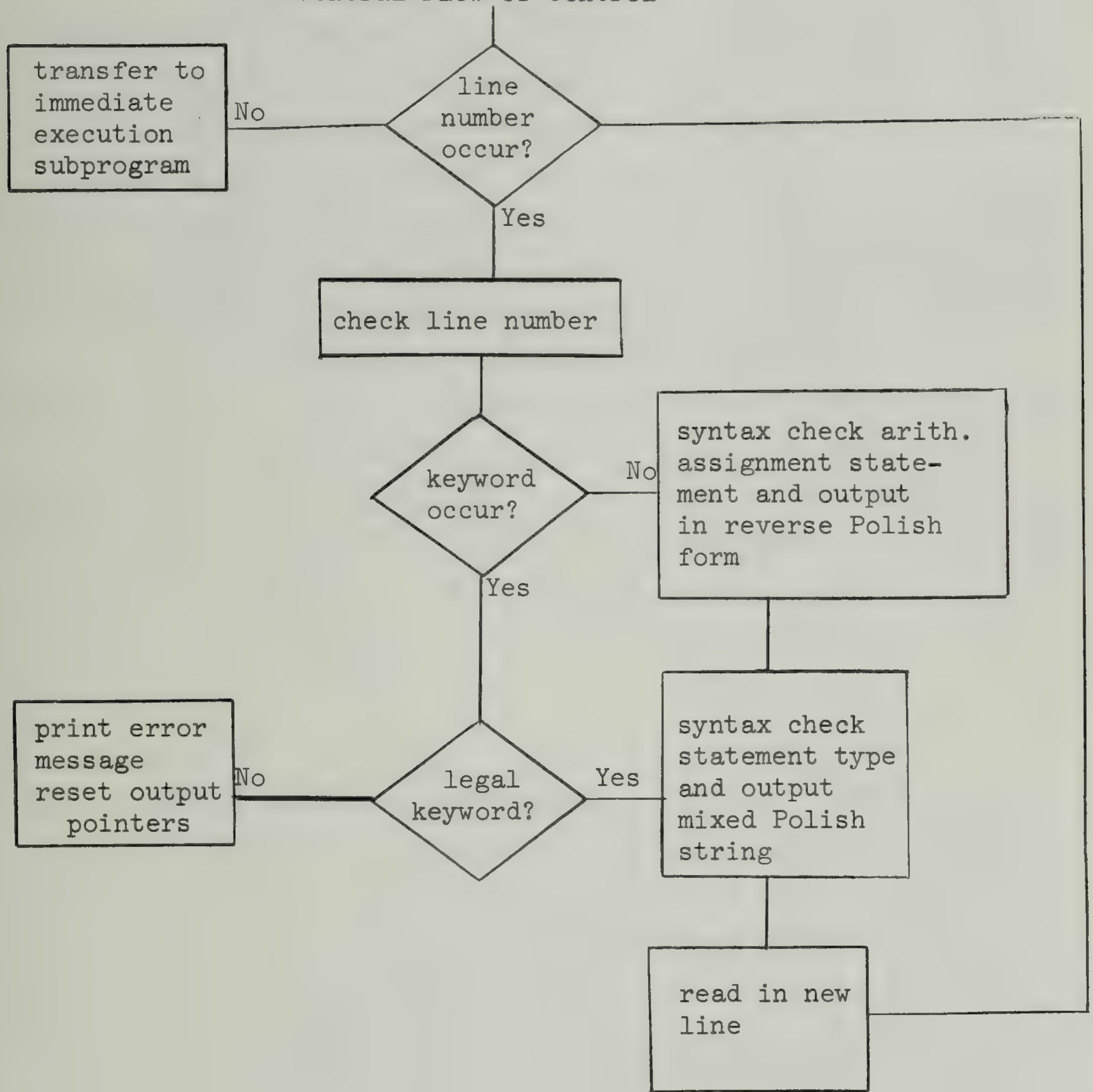
3.3.5 Pass 1: Initial Syntax Scan

The first version of the first pass has been completely written and partially debugged. General flow of control is as shown in the accompanying chart.

The immediate execution subprogram handles lines input without line numbers. These lines are the command system. The commands will be defined with the end in view of having them conform as closely as possible to the syntax requirements of the PL/I language: the actual termination of Pass 1 and initiation of Pass 2 and the Executor will be handled by commands.

The basic routines of Pass 1 are described below. Backus Normal Form is employed in the discussion of arithmetic assignment statements; keyword statements are syntactically defined in the notation used by IBM in their specifications for the PL/I language. In either case, the symbol ␣ denotes one or more spaces (blanks).

General Flow of Control



Arithmetic Assignment Statement Syntax

```
<assignment statement> ::= <line number> <label list> <identifier list>
                         = <expression>
<line number> ::= <empty> | <digits> ␣ | <digits>.<digits> ␣
<digits> ::= <empty> | <digit> | <digit> <digit> | <digit> <digit> <digit>
<label list> ::= <empty> | <label>:<label list>
                 not more than 7 labels, containing not more than 63
                 nonblank characters, per line
<label> ::= <identifier> | <identifier> (<constant subscript list>)
<constant subscript list> ::= <constant expression> |
                 <constant expression>,<constant subscript list>
                 not more than 7 expressions in any one list
<constant expression> ::= <expression consisting of operators and constants only>
<identifer list> ::= <identifier> | <identifier>,<identifier list>
<expression> ::= <variable> | (<expression>) | <unary operator> <expression> |
                 <expression> <operator> <expression>
<variable> ::= <constant> | <identifier>
```

3.3.6 Keyword Routines for Pass 1

Upon entry to the KEYWORD recognizer, the suspected keyword is in IDENTBUF. The byte preceding IDENTBUF contains the character count. This count is used to determine the appropriate section of the keyword table to be searched. If the number of characters is less than 2 or exceeds 9, an error return is given, since all keywords recognized by PLORTS are between 2 and 9 characters. All keywords having the same number of characters are grouped together in the table. The format of each entry in the keyword table is as follows:

Bytes 1-N ($2 \leq N \leq 9$)	Byte N+1	Byte N+2
Characters of keyword (in byte internal form)	Flag byte	Keyword type code

The flag byte is 1 if the keyword is the last one of a given length; otherwise it is 0. The routine does a logical compare of the N characters of IDENTBUF with the N characters of the table entry. If the compare fails, the flag byte is checked. If this byte is 1, the contents of IDENTBUF is not a valid keyword and an error message is printed. If the compare is successful, the keyword type is entered into the first byte of the output string for the line and control transfers to the appropriate routine to syntax check the remainder of the statement, unless the statement is of a type not allowed in PLORTS, in which case the branch is to a section of code which loads an error message and branches to ERROR.

ERROR

The error routine at present does the following: the error code is contained in R1 (general purpose register 1). If the code is even, the error is non-fatal; if odd, fatal. A fatal error is defined as one which causes the line to be deleted; the error code number is printed and the line number is removed from the line number table and the output string pointer (R7) reset to its value before the line containing the error was entered. In the case of non-fatal errors, the error number is printed and control passed back to the calling routine.

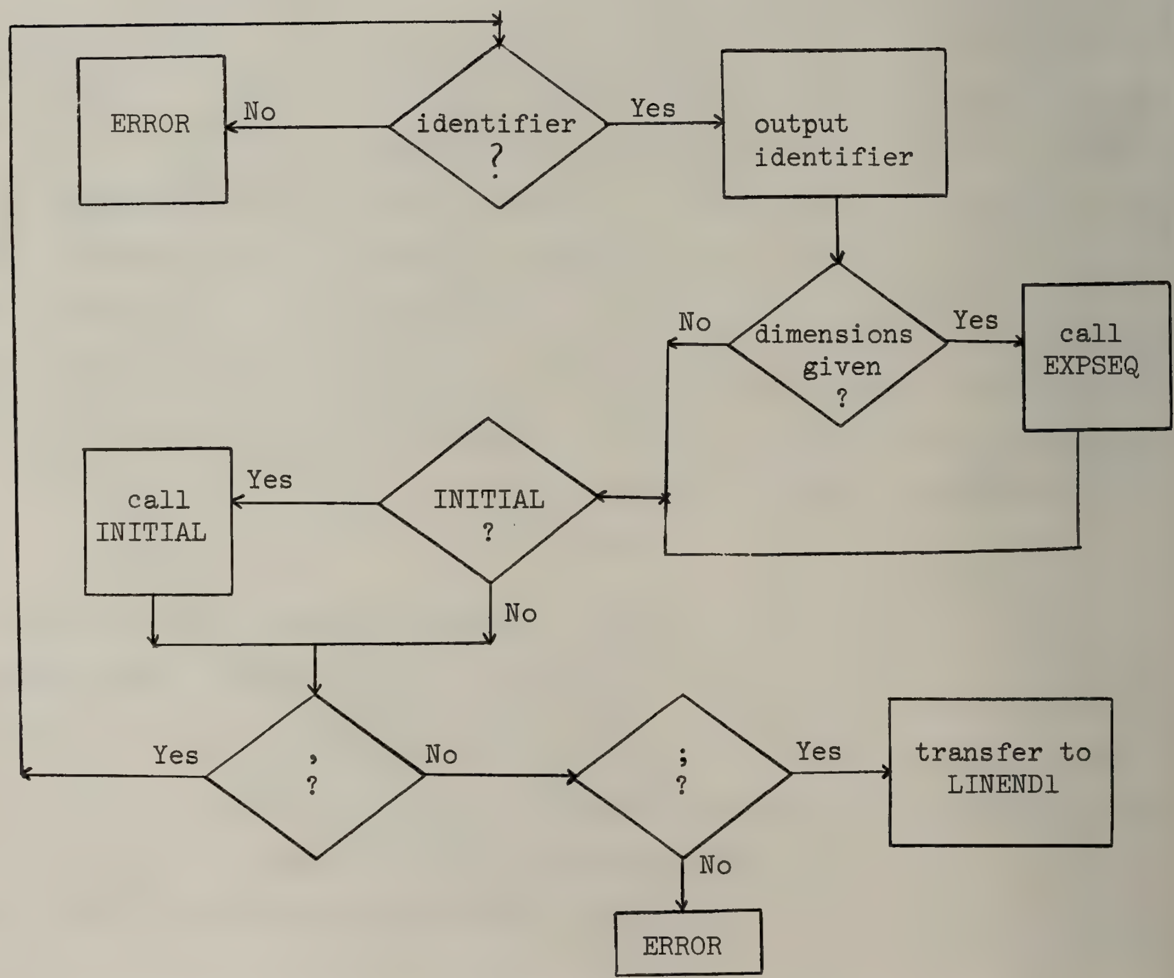
The separate statement syntax check routines are described below, along with their related subroutines. The identifying keyword of the statement is assumed to have been identified upon entry to the routine, and the input string pointer points to the next nonblank character following it.

ALLOCATE

Syntax: ALLOCATE␣identifier [(expression[,expression]...)]
[,identifier[(expression[,expression]...)]...
␣[INITIAL(expression)]...];

Format of output string:

Byte	0	statement type code
	1-7	internal form of identifier
	8	flag table
	9-N	expression corresponding to INITIAL if present
	N+1-N+7	internal form of identifier
	etc.	



BEGIN

Syntax: BEGIN;

Output string format: Byte 0 Statement type code

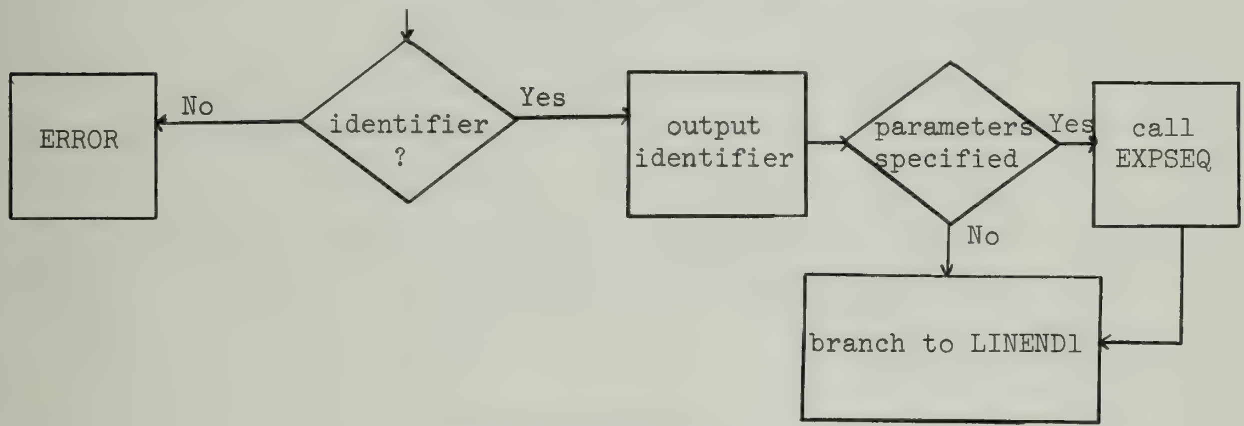
There is no syntax check routine; if the keyword BEGIN is recognized, control is passed from KEYWORD to LINEND1.

CALL

Syntax: Call␣identifier[(expression[,expression]...)];

Output string format:

Byte 0	statement type code
1-8	internal form of identifier
9-N	reverse Polish form of expression sequence



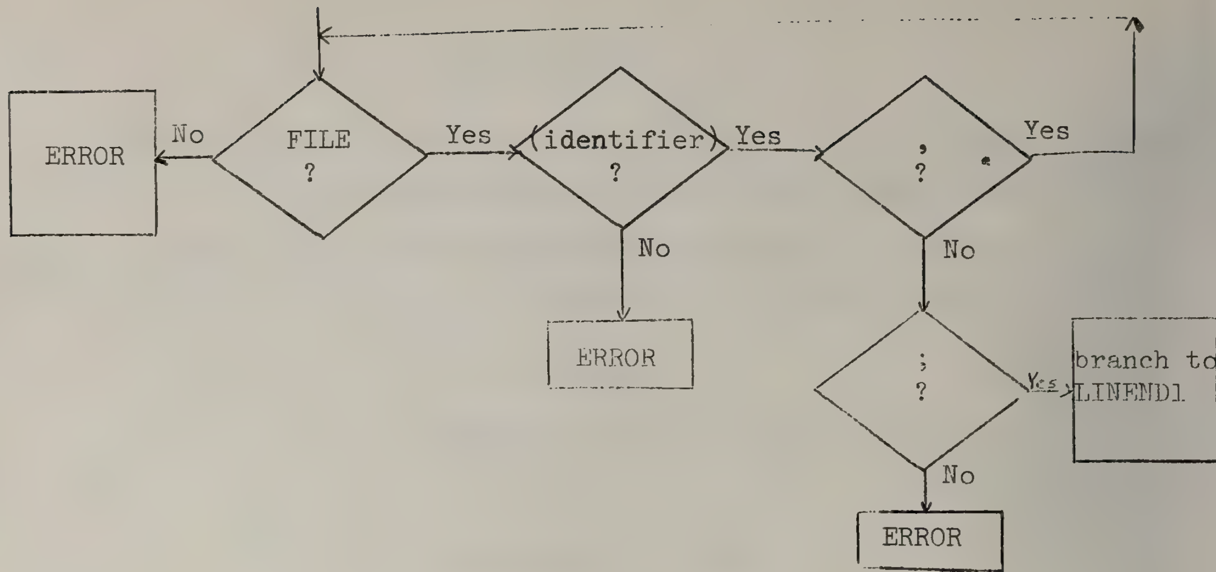
CLOSE

Syntax: CLOSE FILE(identifier)[,FILE(identifier)]...;

Output string format:

Byte 0	statement type code
$1\text{-}N_1$	internal form of identifier
$N_1+1\text{-}N_2$	internal form of identifier
etc.	

The identifier is the name of the file to be closed; N_i is the number of bytes to represent the internal form of the identifier.



DECLARE

Syntax: DECLARE␣identifier[b_1,...,b_n)][␣attribute][␣attribute]...
[,identifier[(b_1,...,b_n)]][attribute][␣attribute]...
[,(identifier[(b_1,...,b_n)][␣attribute]...
,identifier[(b_1,...,b_n)][␣attribute]...)␣attribute,]...;

b_i are bound pairs for arrays; $n \leq 6$

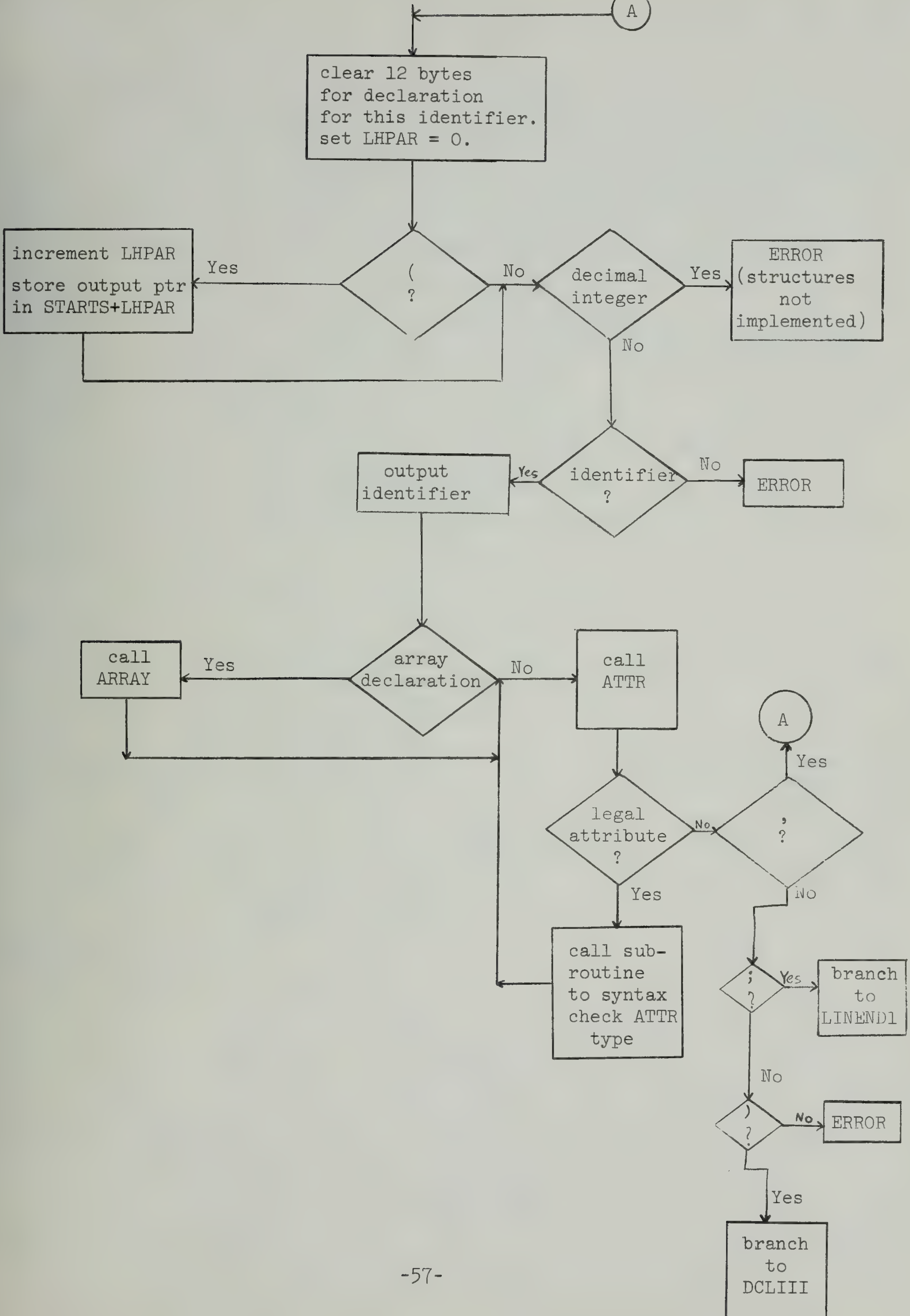
Output string format:

Byte 0	statement type code
1-8	internal form of identifier
9-11	attribute table
12-13	POLISH2 pointer
etc.	

The attribute table has a bit position for every possible legal attribute; the bit is 1 if the attribute occurs, 0 otherwise. POLISH2 is the name of a secondary output string; the POLISH2 pointer, if it is needed, points to a string in POLISH2 which has the following format:

Bytes 0-1	ENTRY pointer
2-3	DEFINED or RETURNS pointer
4-5	INITIAL pointer
6-7	LABEL pointer
8-9	BIT pointer

Each of the above named pointers points to a further string in POLISH2 which contains the further information specified with the attribute named.

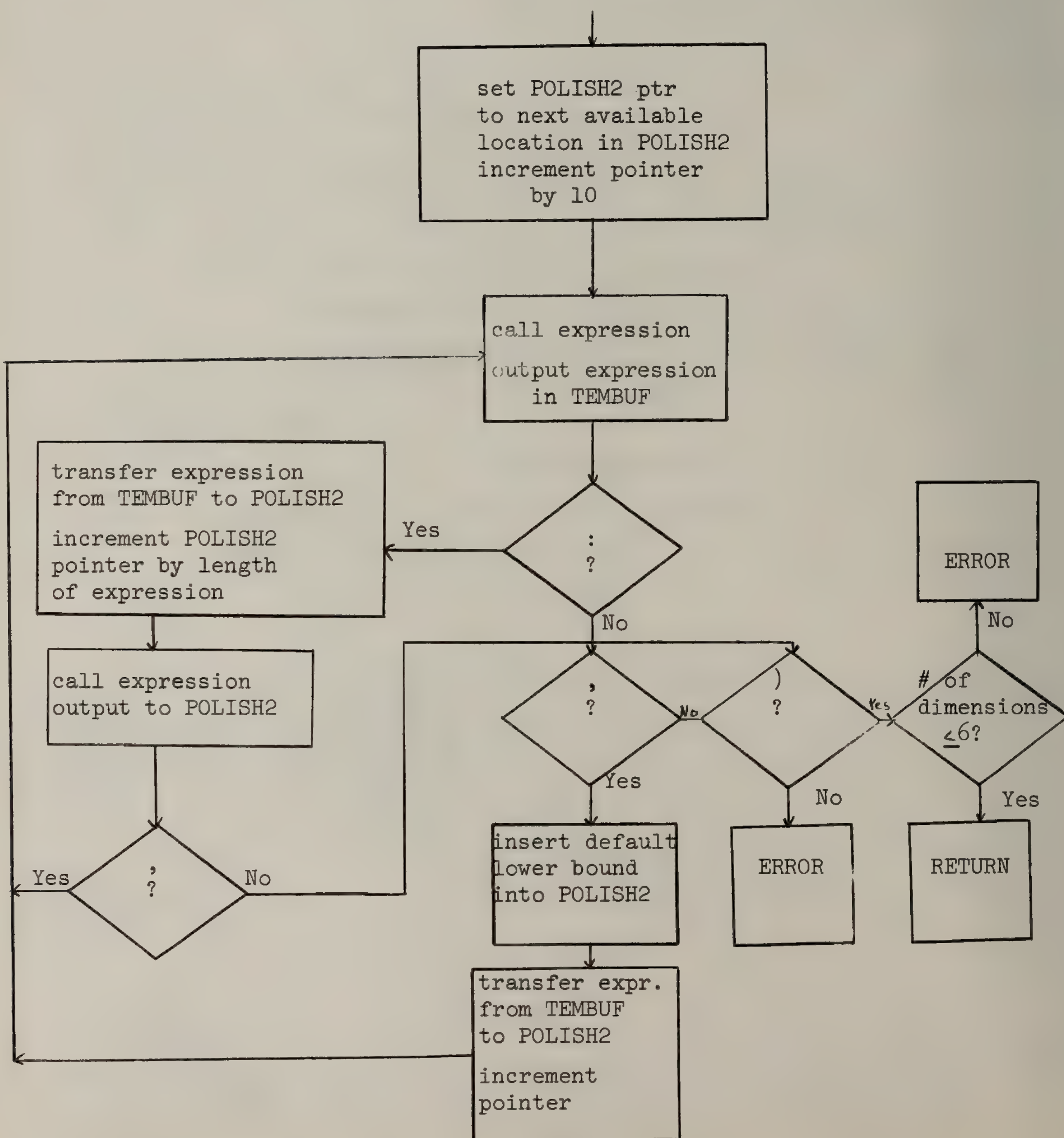

A
clear 12 bytes for declaration for this identifier. set LHPAR = 0.
(
?
Yes
No
increment LHPAR
store output ptr in STARTS+LHPAR
decimal integer
Yes
ERROR (structures not implemented)
No
identifier ?
Yes
No
output identifier
ERROR
array declaration
Yes
No
call ARRAY
call ATTR
A
Yes
legal attribute ?
No
,
?
Yes
No
call sub-routine to syntax check ATTR type
;
?
Yes
branch to LINEND1
No
)
?
No
ERROR
Yes
branch to DCLIII

ATTR

This subroutine checks for an identifier. If it fails, control is passed back to the calling program. Otherwise, it checks for attribute keywords the same way that KEYWORD checks for statement type keywords, the attribute type code in the last byte of each entry being loaded into R1 to be used as a branch index to indicate which attribute routine to branch to (the branch indices for some attributes are the same). Control is then returned.

ARRAY

Output format: expression:expression,...,expression:expression)



DCLIII

DCLIII is the routine for handling attributes which are specified for several identifiers simultaneously by the use of attribute group parentheses. It first compares LHPAR with RHPAR; if RHPAR is greater than LHPAR the right parenthesis is ignored and an exit is taken from the subroutine. Otherwise the location STARTS contains the pointer to the first declaration for which the grouped attribute applies. Each grouped attribute is entered into the attribute table for each identifier to which it applies. If the attribute requires a further information pointer this is also entered successively into each declaration output string for an identifier to which it applies. Attribute compatibility is also checked at this point. The routine generally works by calling the individual attribute routine, and if no error is found, successively entering the bit in the proper place in the relevant attribute tables. If a secondary information pointer is required, this is handled by a special subsection names DCLGA; its action is similar.

Syntax and handling of individual attributes will be explained in the next section.

DO

Syntax: DO; | DO␣WHILE(expression); |
DO␣identifier=specification[,specification]...;

where <u>specification</u> is expression |
expression␣TO␣expression[␣BY␣expression] |
expression␣BY␣expression[␣TO␣expression] |
expression␣WHILE␣(expression)

Output string format:

Byte 0	keyword type code	
1	option table:	1 in bit 0 indicates the first of the above options, 1 in bit 1 the second, and 1 in bit 2 the third.

If the first character after DO is a semicolon, bit 0 is set to 1 and control is passed to LINEND1. In the case of option 2, the reverse Polish form of the expression in WHILE(expression) follows byte 1. In the case of option 3, the format for each specification is:

Bytes 2-9	internal format of index identifier
10-11	pointer fo first expression (must appear)
12-13	pointer to TO expr if present, otherwise 0
14-15	pointer to BY expr if present, otherwise 0
12-13	pointer to WHILE expression if TO or BY do not appear

END

Syntax: END[␣identifier];

Output string format:

Byte 0	keyword type code
1-7	internal form of identifier (if present)

ENTRY

Syntax: ENTRY[(parameter[,parameter]...)][␣data-attributes];

Output string format:

Byte 0	Keyword type code
N_i-N_i+6	internal form of identifiers which are the parameters (i = 1,...,n-1)
N_n+1-N_n+3	attribute table

If a left parenthesis is found, the identifiers are output in internal form until a right parenthesis is reached. The data attributes are handled by ATTR, but the table is checked after each new attribute. If any attribute other than an arithmetic attribute is found, a fatal error exit occurs.

EXIT

Syntax: EXIT;

FREE

Syntax: FREE␣identifier[,identifier]...;

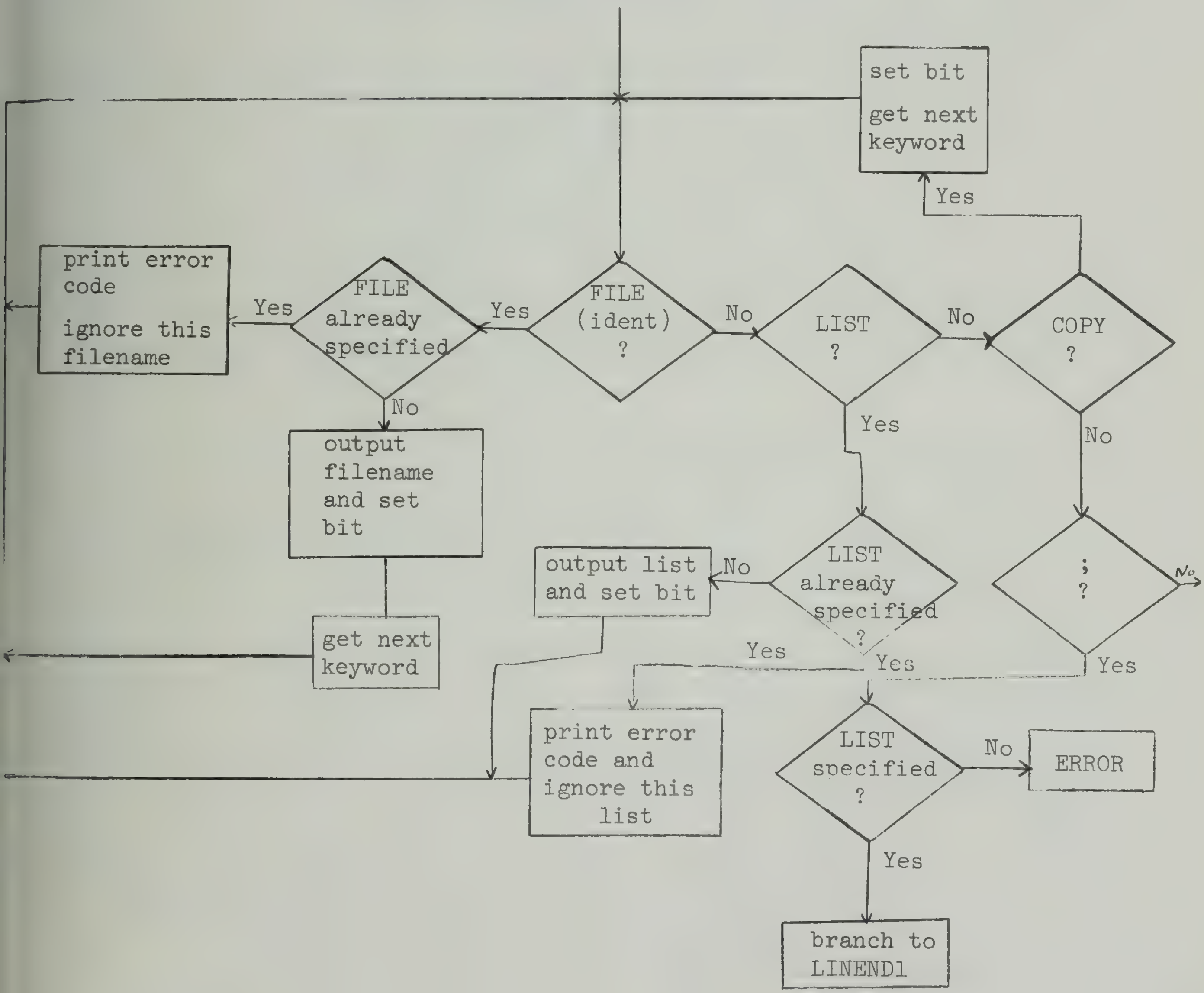
Output string format:

Byte 0	keyword type code
N_i-N_{i+1}-1	internal form of ith identifier

Syntax: GET[␣FILE(filename)]␣LIST(identifier[,identifier]...)[COPY];

Output string format:

Byte 0		keyword type code
1		option table:
	bit 0 = 1:	filename occurs, in which case bytes 1-7 contain the internal form of the identifier
	bit 1 = 1:	COPY option has been specified
	bit 2 = 1:	a list has been specified. The list of identifiers in internal form follows the option table and the filename identifier (if it occurs).



GO TO

Syntax: GO␣TO | GOTO [␣label]

Output format:

Byte	0	keyword type code
	1-end	internal form of label identifier followed by subscript list (if label is subscripted) in reverse Polish

IF

Syntax: IF␣expression␣THEN[␣statement][␣ELSE␣statement]

Output string format (IF part):

Byte	0	keyword type code
	1-2	pointer to THEN clause
	3-4	pointer to ELSE clause (if present)
	5-end	expression in reverse Polish

The THEN and ELSE clauses are considered separate statement types to allow longer expressions and clauses than would be possible under the standard PLORTS one-line restriction. Hence the need for the pointer, which is inserted in Pass 2.

Output string format (THEN part):

Byte	0	keyword type code for THEN
	1	keyword type for statement following THEN
	2-end	output from statement

The syntax check is done by examining the keyword following THEN; if it is a legal keyword, it is checked sequentially against the keywords END, PROCEDURE, DECLARE, FORMAT, ENTRY, and IF. If it is one of these a fatal error results; if not, control passes to KEYWORD and the statement is syntax checked and appropriate output produced.

Output string format (ELSE clause):

Byte 0 is the keyword type code for ELSE; the ELSE is seen and control is transferred into the THEN routine.

OPEN

Syntax: OPEN␣FILE(filename)[␣INPUT|OUTPUT][␣PRINT][,FILE(filename)...]...;

Output string format:

Byte 0		keyword type code, followed by the individual outputs for each file, as follows:
Byte 0		option table
	bit 0 = 1:	FILE specified
	bit 1 = 1:	INPUT
	bit 2 = 1:	OUTPUT
	bit 3 = 1:	PRINT

PROCEDURE

Syntax: PROCEDURE[(parameter[,parameter]...(][␣OPTIONS(MAIN)]
[␣RECURSIVE][␣data attributes];

Output string format:

Byte 0		keyword type code
1		option table
	bit 0 = 1:	OPTIONS(MAIN)
	bit 1 = 1:	RECURSIVE
	bits 2-6:	number of parameters
2-4		attribute table
5-end		internal form of identifier parameters

When a keyword is recognized, it is checked against OPTIONS(MAIN) or RECURSIVE; if it is one of these, the bit is set in the option table. Otherwise it is handled by ATTR. Then the table is checked to see if the attribute is arithmetic or bit string type. If it is neither, a fatal error occurs. If it is accepted, the next character is checked. If it is alphabetic and heads a keyword, the above check is run on it. If it is a left parenthesis the count is checked. If it is nonzero a fatal error occurs. The identifiers of the parameters are output, and the count is entered in byte 1. If the character is neither, an error is flagged. Then the next character after the parameter list is examined until the end of the line occurs.

PUT

Syntax: PUT[␣FILE(filename)]LIST(identifier[,identifier]...)

The output and syntax check are the same as for GET, except that if COPY is specified it is ignored and a nonfatal error is indicated.

RETURN

Syntax: RETURN; | RETURN(expression);

Output string format:

Byte 0	keyword type code
1-end	reverse Polish form of expression, if any or at all

STOP

Syntax: STOP

Output string format: Byte 0 = keyword type code

The above, briefly, are the syntax checking routines. At the end of such syntactically correct line, control is transferred to LINEND1. If the end of the line is reached but no semicolon is found, GETCHR supplies one.

At the end of the quarter, all the routines mentioned above and in the next section exist. KEYWORD, ATTR, and LINEND1 have been debugged and are perfect.

3.3.7 Attribute Checking Routines

EEUSKP

The attributes ENVIRONMENT, SETS, USES, KEYED, and POSITION are recognized by this routine. These attributes are ignored if specified and a nonfatal error message is generated.

ABDEIPRT

The attributes ALIGNED, ABNORMAL, BUILTIN, BACKWARDS, BUFFERED, DIRECT, EVENT, EXCLUSIVE, IRREDUCIBLE, NORMAL, PACKED, POINTER, RECORD, REDUCIBLE, SECONDARY, SEQUENTIAL, STREAM, TASK, UNBUFFERED, and VARYING are recognized by this routine. These attributes are ignored if specified and a nonfatal error message is generated.

CELLIKE

The attributes CELL and LIKE are handled by this routine, which generates an error message and ignores the rest of the line.

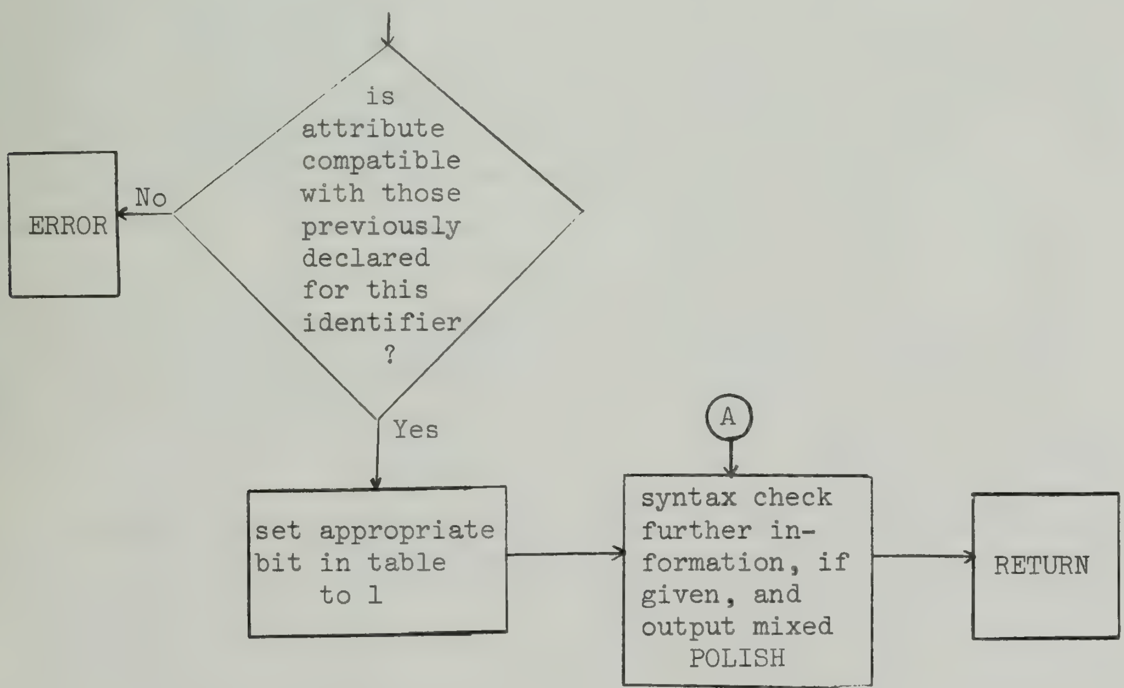
ACCG

This routine handles AREA, CHARACTER, and GENERIC. It first prints the nonfatal error code. If the keyword is not followed by a left parenthesis, the routine returns. Otherwise it examines the subsequent string until the left and right parenthesis counts are equal, then returns. If the end of the line is reached before the counts are equal, there is a fatal error; the routine branches to ERROR.

PICTURE

This routine handles the PICTURE attribute. The string following the keyword is read from the initial to the terminal single quote marks and a nonfatal error code is printed. If the end of the line occurs before the terminal single quote mark, a fatal error branch to ERROR occurs.

The preceding routines all handle attributes not implemented in PLORTS; those that follow are for attributes which are implemented. The general flow of control for all these routines is as follows:



The compatibility check is done via a sequence of three TM (Test under Mask) instructions, one for each byte in the attribute table. The branch index also indexes a mask list. Each entry consists of the three compatibility masks. The table is tested against these masks. Any tested bit which is on indicates an attribute compatibility error. If no such error occurs, the branch index indexes a list each entry of which consists of a three-byte number which is OR'ed into the attribute table to set the appropriate bit. The following descriptions refer to the action equivalent to Box A in the flowchart.

BDCRFF

This handles the attributes BINARY, DECIMAL, COMPLEX, REAL, FLOAT, and FIXED. The precision attribute, if it occurs, is read through and ignored, and a nonfatal error code is printed.

CEAPOIS

This handles CONTROLLED, EXTERNAL, AUTOMATIC, INPUT, PRINT, STATIC, INTERNAL, OUTPUT, and FILE. Box A is empty in this case.

DCLDEF

This handles the DEFINED attribute.

Syntax: DEFINED_identifier[(e_1,...,e_n)]

Here $n \leq 6$, and e_i is an expression in which the iSUB dummy variable may occur; iSUB for some i, $1 \leq i \leq 6$ must occur in (e_1,...,e_n). The DEFINED pointer points to the beginning of the reverse Polish form of identifier (e_1,...,e_n). First the identifier is checked; if a left parenthesis occurs, then EXPRSN is called for each e_i with the "iSUB legal" flag set. Each occurrence of iSUB results in a flag being set at iSUBL+i. If iSUB occurs, the value of i is checked against the number of dimensions for the identifier having the DEFINED attribute. If i > d a fatal error results. When the right parenthesis is reached, iSUBL is checked. If no flag has been set a final error results.

Output string format: expression,...,expression), where expression is in reverse Polish.

DCLEN

This handles the ENTRY attribute.

Syntax: ENTRY(parameter-attribute-list[,parameter-attribute-list]...)

Output string format:

Bytes	0-7	internal form of identifier
	8-10	attribute table
	11	number of parameter attribute lists
	12-15	parameter attribute table
	16-17	POLISH2 pointer
	18-23	parameter attribute table and pointer
	etc.	

Attributes associated with an identifier with the ENTRY attribute are not allowed to be factored. The above is the format for the declaration of an identifier which has the ENTRY attribute. Each parameter attribute list is handled as a declaration for an identifier except that the parameter attributes are also checked for validity.

DCLIN

The DCLIN routine handles the INITIAL attribute.

Syntax: INITIAL (item[,item]...)

The INITIAL pointer points to the string (item[,item]...). The syntax check routine was written using an M-machine program, a technique developed in the theory of pushdown store automata.

DCLBIT

Syntax: BIT (e)

Output: The BIT pointer points to a string that is the reverse Polish form of e, which may be an expression or *.

DCLLAB

Syntax: LABEL[(identifier[,identifier]...)]

Output format: The LABEL pointer points to the string:identifier,..., where the identifiers are in internal format.

DCLRET

Syntax: RETURNS[(attribute[␣attribute]...)]

Output: The RETURNS pointer points to a location in the secondary string which consists of three-byte attribute tables. Each attribute is checked as usual except that in the above table a bit is set indicating that only arithmetic attributes are legal.

P. G. Boekhoff
J. Christopher
J. Roman
W. Demlow

3.4 Ordinary Differential Equations

The Syntax-Oriented Compiler for differential equations is nearing completion. A recognizer and Syntax checker for the IBM 360 has been coded and debugged.

The first phase of the transducer for the Compiler is also finished. This accepts decimal constants and converts them to normalized floating point hexadecimal constants. Decimal constants in the form $\pm d_1, \ldots \; d_k \cdot d_{k+1} \ldots d_n$ $E \pm C_1 C_2 C_3$ are accepted, where the only formal requirement is that there be at least one decimal digit. The range of the constants is the same as those expressable in double precision on the 360 (5.4×10^{-79} to 7×10^{75}).

The constant conversion program has been merged with the recognizer phase of the Compiler. Constants are properly recognized and converted to hexadecimal with accuracy equal to that of the 360 Assembler in most cases.

The Intermediate Language form for the Compiler is a doubly linked list (tree) in which the list entries will each be one word (32 bits) in length. This form is well-suited for the optimization of object code, the simplification of derivative expressions, and the optimal usage of index (floating point) registers in the object program.

Typical Entry:

	Operation Code		Address A	Address B
Bit Number	0—3	4,5	6—18	19—31

Function Entry:

9		Function Name	Address B
0—3		6—18	19—31

Unary Minus Entry:

4		0	Address B
0—3		6—18	19—31

Operation Codes

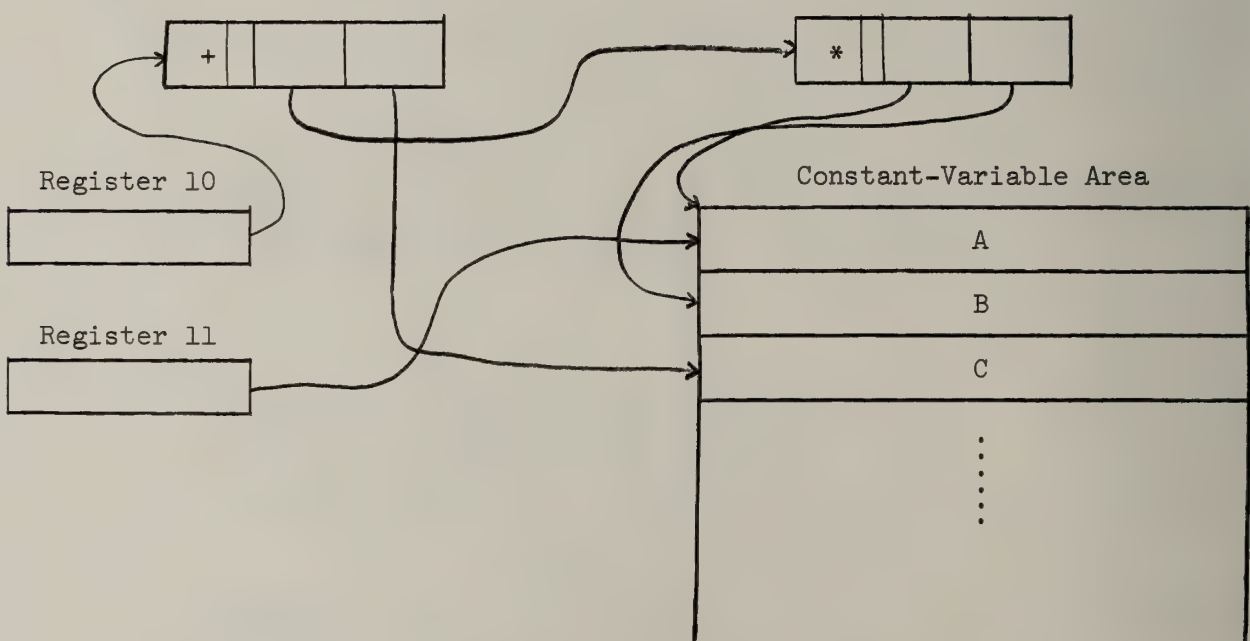
+	1
-	2
$-^{-1}$ (inverse subtract)	3
⊖ (unary minus)	4
*	5
/	6
$/^{-1}$	7
**	8
function	9

<u>Index Register Assignment</u>

Register 10 = Top of stack pointer

Register 11 = Constant-variable area

As an example, A*B+C would compile to the following intermediate language list:



The final phase of the Compiler, which generates code from strings produced in the Intermediate Language, has been programmed. The output code is produced by a recursive subroutine which is capable of producing code for the operations: addition, subtraction, inverse subtraction, multiplication, division, exponentiation, inverse division and unary minus, received from the Intermediate Language. This subroutine also implements Fortran subroutines for special functions, such as sine and cosine, generally available in Fortran. Nesting of functions is permissable to any level. The final phase has not yet been debugged.

Both the intermediate and final phases of the compiler have been designed to minimize the number of floating point registers used in the object program.

Before the Compiler can be implemented, an initialization program, now in the planning stage, must be written. This program will handle user input data. It will accept data such as differential equations, initial values, the interval of integration, the printing format for the results, and frequency of printing. (Also intermediate variables to be printed will be able to be specified.)

The Fortran program which performs the actual integration of the differential equations in its present form makes use of two user-supplied subroutines which give information concerning the particular equations to be integrated. Eventually the Compiler will automatically provide this information in a form which the integration program can use.

The integration program itself has been undergoing tests and modifications in an attempt to find the best combination of variables in the integration scheme (methods, type of error bound, algorithm for deciding when to change the order of the method, etc.)

One group of tests was run on four distinct sets of differential equations, using the fixed order integration program and the order selection program. The results were in the form of graphs comparing the upper bound on the error to the number of function evaluations necessary to advance the solution to a given point. From these results the actual error made in the integration was computed and compared with the number of function evaluations necessary. This information was obtained for stiff and non-stiff methods of

order two through six and for automatic order selection. Results for non-stiff methods on stiffly stable equations could not actually be obtained since the methods were ineffective in terms of time expended to integrate.

The automatic order selection program (to be used in the final differential equations package) has been modified in several ways.

1. A first order method has been added as the order for starting the integration.

2. There are two versions of the program, one which uses absolute error bounds and a second which uses error bounds relative to the magnitude of the solution at a given point (in this case the bounds are recomputed when the corrector fails to converge or the order is changed).

3. The order of the method could previously change after each step taken in the integration. The tests for oder change are now only allowed when the step size can be doubled, which implies that a certain minimum number of steps have been taken since the last order change.

4. Modifications are currently being made in the criteria for order selection.

Tests are also in progress to determine the effectiveness of the order changing process and the relationship between stability of equations and type of methods (stiff or non-stiff) used.

In the near future it is hoped that the compiler can be combined with the Fortran integration program.

C. Dill
C. A. Ellis
K. Ratliff

3.5 Low-Cost Graphics Terminal

3.5.1 Design

A firm detailed logical design for the display controller, a well-specified design for the general machine architecture, and a 90% firm order code for the CPU has been formulated this quarter. The display controller is waiting for delivery of the integrated circuits for construction to commence. The detailed logic for the CPU has yet to be drawn. A description of the current state of design has been prepared as a file number. The bus structure of the CPU, the tentative order code and the logical design of the display controller are presented in that document.

The tentative order code has been used to program some of the graphics system routines to gauge the order code's applicability. The basic CalComp line drawing algorithm was coded, and found to take 52 milliseconds to generate the increment codes for 10" of display vector. This indicates that the machine will be CPU limited when generating pictures, although the refresh of the display with a previously drawn picture will be independent of the CPU. A code for searching the display stream for a figure and updating it was also designed, showing that the display updating can be done without losing disk revolutions if the updating isn't too complicated. Numerous additions were made to the display hardware to minimize display interference from the CPU on the basis of this investigation.

3.5.2 Hardware Testing

Using patch board kits for integrated circuit designing, a number of counters were wired up to check carry propagation times. A 10 bit full predictor counter was run at about 17 mc, the limit of the test equipment. The carry propagation time was around 50 nsec; to minimize the disturbance to the D/A convertors, this counter will probably be used in the X and Y registers.

An integrated circuit configuration for testing a 10 bit full adder function, 3 jam transfer registers, and a digital to analog converter was designed, built and checked out. The control was arranged so that all time parameters could be varied. It is generally agreed that a 10 bit full add utilizing TISN7482' adder elements can be accomplished in less than 100 nanoseconds.

The first of the 100 pattern (plug) 16 mounting panels was brougnt up from the shop and sockets fixed to it. They were found to be satisfactory for the terminal.

Some amount of work and study were performed in an attempt to reduce the flicker on the 338 display by filtering with an amber filter. The light pen of the 338 does not respond to yellow light, so a light pen was borrowed from the Artrix project. Some difficulty was encountered because of the filter. While filtering the display effectively, some intensity reaction was very apparent. This tends to indicate either a very sensitive light pen or a more efficient filter.

Logic was finalized for the Ampex memory control and a panel wired for the control.

The control is composed of about 90 IC's and was viewed as a legitimate test for bussing structures, power distribution, power supply filtering, etc. Solutions for problems in all these areas have been worked out satisfactorily.

The Ampex memory is running and appears to be very stable.

A Fairchild 737A large screen indicator was received and a preliminary checkout completed. Having only one D/A converter to check out the Fairchild 737A it was decided that an effort should be made to build our own D/A converter. The first D/A converter was built and the preliminary testing completed.

A decision was made on the disc for the terminal and the order to Data Disc was started. Orders for sockets, integrated circuits and more #30 wire were placed.

A Rush C-100 wire stripper arrived the last week of December. The hand strippers we were using nicked the number thirty (30) wire making wire wrapping connections unreliable.

C. E. Carter
L. Greninger
H. E. Lopeman
R. L. Miller

3.6 Publications

The following publications were produced in this quarter.

1. F. K. Richardson, "A User's Description of the Computer Aided Programming System (CAPS) Programs on the DEC 338", File No. 739, December 19, 1967.

2. F. K. Richardson, T.-Y. Lo, C. W. Gear, "A Computer Aided Programming System", Proceedings of the Computer Graphics Conference held at Urbana, Illinois, November 6-8, 1967. In press. Benjamin Book Company.

3. C. W. Gear, "Automatic Numerical Integration of Stiff Ordinary Differential Equations", submitted to IFIPS, 1968.

4. Publication 2 was presented by Richardson and Gear at the Graphics Conference. Publication 3 was the subject of talks at the Universities of British Comumbia and Alberta in November.

4. ILLINOIS PATTERN RECOGNITION COMPUTER: ILLIAC III

(Supported in part by Contract AT(11-1)-1018 with the U.S. Atomic Energy Commission and the Advanced Research Projects Agency)

4.1 Introduction

Illiac III is an experimental computer being designed and constructed by the Department of Computer Science as a first foray into the world of high speed visual data processing. Besides providing normal computational facilities, the machine includes a parallel processor for visual data processing (the Pattern Articulation Unit) and an extensive complement of visual input/output equipment.

Also reported here are developments (funded by the Advanced Research Projects Agency) which attempt to provide picture processing facilities for remote users with only moderate image-processing demands. The strategy here is to extend processing facility (Illiac III) via a video communications net. Intimately associated with this latter development is the evolving concept of an Information Resource Center.[1] Work is reported on the engineering of microform image files, text reformatting, and elements of information retrieval.

Section 4.2 outlines the system programming developments, which are then discussed in Sections 4.3 - 4.5. Section 4.6 provides an outline of the Illiac III computer system (hardware). The status of each area of hardware design and fabrication is then summarized in Sections 4.7 - 4.13. A bibliography of publications this quarter is given in Section 4.14. Finally Section 4.15 lists the staff of Illiac III, as of December 31, 1967.

The level of status description in the following sections varies widely, and reflects in part whether detailed manuals and reports are either currently available or soon to be issued. Current documentation is normally referenced in context.

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[1] B. H. McCormick and A. M. Richardson, "Design Concepts for an Information Resource Center", Department of Computer Science, Report 203, May 1966.

4.2 Outline of Programming Developments

The section numbers of the outline below correspond to section headings of the Progress Report.

4.3 Manuals

4.3.1 Programming Manual

4.3.2 Scanner/Monitor Manual

4.3.3 IBAL Assembler Manual

4.4 Translators and Simulators

4.4.1 Illiac III Simulator

4.4.1.1 Overall Strategy and Documentation

4.4.1.2 Taxicrinic Processor Simulation

4.4.1.3 I/O Processor Simulation

4.4.1.4 Arithmetic Unit Simulation

4.4.1.5 Pattern Articulation Unit

4.4.1.6 Interrupt Unit Simulation

4.4.2 Scanner/Monitor Simulator

4.4.3 IBAL Assembler Translator

4.4.4 Universal Translator

4.4.4.1 Creation of Floyd Productions from BNF Syntax

4.4.4.2 Prescanners

4.4.4.3 FORTRAN Productions

4.4.4.4 PL/1 Productions

4.4.5 Association Storing Processor (ASP) for Pattern Recognition

4.5 Library Automation

4.5.1 LEFT: Language for Editing and Formatting Text

4.5.2 SEARCH Language

4.3 Manuals

4.3.1 Programming Manual

The Illiac III Programming Manual, first edition, will be completed by February. This manual will serve as an introduction to programming the computer, and also provide a cross reference to more detailed expositions of individual systems, both hardware and software.

As such, the manual is organized from the general to the specific. The first section consists of a general description of Illiac III from an overall view, emphasizing the interrelationships between the various hardware subsystems. This is followed by detailed discussions of each individual hardware subsystem.

Section two systematically lists and describes the instruction repertoire for the various processing units of the computer.

Section three, (which is not included in the first edition) will consist of examples of instruction execution, and summarize the instruction and number formats. It will also include a list of the IBAL mnemonics and a collection of diagnostic messages. Operating instructions will be included in this section.

R. M. Lansford

4.3.2 Scanner/Monitor Manual

The Illiac III Scanner/Monitor Manual by L. Dunn, L. Goyal and V. Tareski contains the basic information necessary for low-level language programming of the Scanner/Monitor and its associated Video Communication Network. The manual includes a description and interpretation of the header words (begin, end, slit and display). These four words contain the coordinates and parameters that specify the details of the information transfer to be performed, and select the storage or display devices between which the transfer is to take place. The direction of the transfer is made explicit by the choice of a Read/Write command following transmission of the header words by the control command.

Also included in the manual is a section stating the constraints imposed on the information in the header words by the Controller Logic, Video Communications Network, and by parameter consistency.

A final section describes the three modes of operation (coordinate, raster and incremental) and their associated data string formats.

L. Dunn

4.3.3 IBAL Manual

This manual describes IBAL, the Illiac III Basic Assembler Language. It is intended that IBAL will be the lowest level language used for Illiac III programs. With suitable constraints upon the naming of operands, each primitive operation in IBAL directly corresponds to one Illiac III machine instruction. The reader should be familiar with the Illiac III machine instructions and their formats as given in the Illiac III Programming Manual.

It is possible to specify information structures more general than those of the machine instructions. A statement in IBAL may be a block, declaration, instruction or directive. Blocks permit the specification of nested structures of statements. Declarations allow specifications of generalized tree-structured data items whose irreducible constituents are the smallest addressable basic elements of the machine. The block structure of IBAL corresponds to the block structure of ALGOL 60 and PL/1.

In comparison to other programming languages usually classified as "assembler languages", IBAL allows very general data declarations. It is believed that this capability is essential to any programming language adequate for the translation of languages as complex as PL/1.

The draft of the IBAL manual[1] has been prepared and typed versions should be available in two weeks.

J. Schwebel

[1]The Illiac III Basic Assembler Language (IBAL), Department of Computer Science Manual, University of Illinois, Urbana, Illinois.

4.4 Translators and Simulators

4.4.1 Illiac III Simulator

4.4.1.1 Overall Strategy and Documentation

The present area of simulation of Illiac III is at the local level. Namely, at present, the following hardware devices are being simulated as separate entities at the logic level.

1. Taxicrinic Processors (TP)
2. Arithmetic Units (AU)
3. Pattern Articulation Unit (PAU)
4. Input/Output Processors (IOP)

This initial depth of simulation has been chosen to facilitate completion and check out of the logical design of the various devices. A first edition of documentation has been completed.

It is recognized that this level of simulation is not well suited to system software investigations. Thus as the simulation and the hardware design are checked out, a second version will be implemented with suitable changes so as to minimize running time. It is at this time that the separate programs will be integrated into the complete system. The current status in each area is given in the appropriate section.

4.4.1.2 Taxicrinic Processor Simulation

Early in the quarter, coding of those TP instructions remaining to be simulated was finished, and debugging was begun. Preliminary documentation was completed for this section.

Later on in the quarter, as a result of the simulation and other studies, it was found to be useful to make certain changes in the hardware operation. In particular, the operand phrase constructions have been considerably extended so as to allow multiple indexing. Changes to the simulator which this necessitated are known but have not at present been implemented.

Changes were also made to the operation of the indicators which are testable by the programmer. The necessary changes have been incorporated, but the documentation has yet to be revised.

All four imprimitive instructions were extensively investigated. As a result, the entire imprimitive sequencing has been revised and in general, simplified. This required a complete rewrite of the corresponding sections of the simulator. The rewriting has been finished and these instructions are currently being tested. A first edition of the necessary documentation has been completed.

R. Lansford

4.4.1.3 I/O Processor Simulation

Definition of Phase I

Phase I of the I/O simulation covers the normal programming interaction with the I/O Processor (IOP). This includes the description and operation of the Program Registers and Commands. Three other areas are closely related to the programming area but are not generally considered part of Phase I. These are (1) channel operations, (2) interrupt operations, and (3) overall IOP control sequences.

Status of Phase I

The following Program Registers and their operations have been described and simulated in PL/1 code.

Pointer Registers
Base Registers
Command Registers
Status Registers

The following Device Independent Commands which represent the main bookkeeping functions of the IOP have been simulated in PL/1 code.

Load Data Pointer Register
Store Data Pointer Register
Load Command Pointer Register
Store Command Pointer Register

The Device Dependent Commands, READ and WRITE were pseudo-simulated (since channel operations were not fully simulated in Phase I).

In order to test the above mentioned registers and commands, an I/O program was written which contained the following features:

(1) looping a variable number of times,
(2) variable data byte counts and variable data pointers,
(3) control of two different devices on separate channels,
(4) complete independence from the supervisor (except in starting the program).

Results of Phase I

In general the preliminary results of the Phase I simulation confirm the workability and logic of the design of the IOP Program Registers as described by Cederquist and Hayes. Thus their design will be used with modifications as suggested below.

The simulation also indicated the need for certain minor changes in program register organization and usage which should (1) facilitate multiple-channel programming and (2) protect one channel from programming errors executed by another channel's program. With these modifications it should be possible to debug I/O programs in a multiplexing I/O Processor which is executing many "perfect" and "imperfect" I/O programs at the same time.

In addition, the Phase I simulation has provided the information necessary to further the design of related areas such as the IOP interrupt system. About 10 new flowcharts were drawn in this area. These should be useful in Phase III (see below).

Phase II and Phase III

Phase II of the I/O simulation will cover the channel registers and channel servicing operations. Phase III will cover the interrupt registers and the interrupt system operations. Simulation of the crucial timing aspects of the IOP will be a part of Phase II, which will continue into Phase III.

With the completion of Phase III the overall design of the IOP will be ready for extensive testing. Many of the design criteria established by G. Cederquist in his thesis, "An Input/Output System for a Multiprogrammed Computer" will then be re-examined and retested using the new simulation which will then be more comprehensive, more realistic and more detailed than previous ones.

L. Katoh

4.4.1.4 Arithmetic Unit Simulation

The clock-mode of the arithmetic unit has been simulated. The entire simulated arithmetic is treated as one routine which consists of 9 parts: control section, addition, subtraction, compare algebraically, multiply, divide, convert to long fixed-point number, convert to floating-point number, convert to decimal and polynomial evaluation. A special subroutine FIXUP is used to bypass the 360/75 operating system in case of overflow, underflow and loss of significance.

All orders, except data conversion orders and polynomial evaluation, are simulated by corresponding orders in 360/75. Polynomial evaluation (POLY) is simulated by exactly the same logic used in the hardware design: initiation of POLY, continuation of POLY (require next coefficient) and termination of POLY. Interruption is checked by the simulated arithmetic unit; if so, the partial result will be sent back to the Taxicrinic processor. POLY may be resumed exactly as interrupted.

As the result of this simulation several design faults and/or omissions have been discovered, and the treatment of exceptional conditions has been extensively reworked.

Status: The simulated arithmetic unit is completely debugged (further changes may be needed for corresponding changes in hardware) and documented.

4.4.1.5 Pattern Articulation Unit

Up to now work has been concentrated on completing the operating specifications (i.e. semantics) of the PAU order code. This has been completed and is presently being included in the appropriate manuals.

In order to facilitate design of the PAU control logic, the PAU will be simulated at the control logic level. The language to be used is PL/1.

At present only a rough outline of the simulation has been completed.

R. Lansford

4.4.1.6 Interrupt Unit Simulation

No progress has been made during the last quarter.

4.4.2 Scanner/Monitor Simulator

Simulation of the control logic is being done with the two following purposes in mind:

1) to detect and correct any errors in the control flow charts, and

2) to evolve systematically from an initial approximation to a higher-level language for programming the Scanner/Monitor.

Since a real-time simulation cannot be accomplished, any timing conflicts that might arise will not be detected.

L. Dunn

4.4.3 IBAL Translator

The structure of the IBAL translator as explained in the last quarterly report (July, August, September 1967) has been modified to reflect changes in the language. These changes are included in the IBAL manual referred to in Section 4.3.3.

Since, as in PL/1, declarations may appear anywhere within a block the declarations will be analyzed prior to the pass which performs the complete syntax check. (Compare with the PL/1 productions, Section 4.4.4.4.

Consideration was given to the idea of using a simple precedence matrix for the syntactical check. This does not look promising, however, due to the complexity of the semantic interpretation rules which are required.

J. Schwebel

4.4.4 Universal Translator

4.4.4.1 Creation of Floyd Productions from BNF Syntax

This system, currently being programmed, is an implementation of the ideas of Eickel and Paul expressed in their paper, "The Parsing and Ambiguity Problem for Chomsky Language" (T. H. Munchen, Bericht Nr 6409) for solving the parsing and ambiguity problem for a given Chomsky - 2 grammar. The input of the system is BNF definition of the language and the output is a purposive scanning system for the language, or else a notation that the set of production rules for reducing a given string is not unique.

In the current implementation the input is assumed to be in either extended or compacted BNF form. Each such production is expanded into the set of corresponding single productions, and each of the latter is further expanded so as to obtain a simple Chomsky system i.e. where each production has length ≤ 2 and all productions having the same symbol as the right side (the critical productions) are collected as a subset of the productions of length 1. Then a procedure is developed to 'determine' or distinguish between the critical productions by building up context for each member of a set of critical productions with the same right side. From this a purposive scanner is developed.

The first section of this system has been programmed in PL/1. It reads from cards its BNF productions expressed in a free field format where the meta symbols are offset by periods to distinguish them from similar symbols which may appear in the definition of the language. From this scan the symbol table is built up, where the set of non-terminal symbols are decided by virtue of their being a left side of same BNF rule. The productions are then reduced to a simple Chomsky system by the introduction of dummy symbols.

The set of all productions created in this way are collected in three tables - one containing all productions of length 2, one containing all productions of length 1 which are not critical, and all the critical productions.

4.4.4.2 Prescanner (Lexical Analysis)

During the quarter the lexical analysis system written in PL/1 was debugged. The target language chosen was PL/1. The system was able to read in the set of keywords in PL/1 (regarded here as reserved words), and then to scan the sample program which was input. The output consisted of a numbered listing of the card images, a listing of the output string of symbol numbers and table dumps described below. Error messages are also printed noting any illegal characters that may have been punched on each card.

During the scan identifiers are collected and compared to the elements in the symbol table. If the identifier is not in the table it is added as a new entry. A similar procedure is followed for numerical and string constants and a separate table of these quantities are built up. As each symbol is read in the scan, its corresponding line number in the table is entered in the output string. Thus the output string consists of a list of numbers representing the basic symbols in the language, and this string would be passed to the syntax scanner for syntactic analysis.

At the end of the scan the output string is printed out together with a dump of the symbol table, the constant table and the string table, together with the associated line numbers in the table for each symbol.

A. McInnes

4.4.4.3 FORTRAN IV Productions

During this quarter, Floyd Productions were written for FORTRAN IV. The grammar conforms to the IBM System/360 FORTRAN IV Language as presented in File No. S360-25, Form C28-6515-4.

Since FORTRAN is a relatively simple language, only one pass in addition to the prepass is necessary to analyze the syntax of a program.

Approximately one-half of the productions have been typed onto cards, and the remaining are in the process of being typed. A file note describing the productions is in preparation.

R. Hecht

4.4.4.4 PL/1 Productions

The compilation of PL/1 through the use of the universal translator is divided into three parts: the lexical analysis, the declaration pass, and the compilation pass. The lexical analyser accepts a program in the source language, deletes comments from it, and groups such things as identifiers, constants, compound punctuation marks and keywords, and replaces them with their internal representation numbers. The string representing the program in internal number form and the tables telling what the internal numbers correspond to in the source language are then passed on to the declaration pass. This pass recognizes all explicit, contextual, and implicit declarations in the program and builds up a set of tables giving the description (including scope) of each name. The program string and name tables are then passed on to the compilation pass, which does the detailed syntactical analysis and compiles object code. While it is not necessary for the lexical analyser to go through the entire program before the declaration pass is started, it is necessary for the declaration pass to be completed before the compilation pass is started as it is necessary for all declarations to be found and default attributes assigned before any actual compilation can take place.

PL/1 compile-time facilities are not currently being implemented, however they could be added to the system by inserting a compile-time interpreter which would follow the lexical analyser and precede the declaration pass. This interpreter would execute all compile-time statements (i.e. all statements immediately preceded by the symbol %), but leave the statements in the program string. The compile-time statements would then be dropped from the program string during the declaration pass.

The declaration pass had been largely specified during the fall of 1967 in terms of extended Floyd productions. Basically the declaration pass goes through the program (in internal representation form) - statement by statement - looking for and checking all statements which might contain declarations, while at the same time keeping track of the block structure. A name appearing in a position where a contextual declaration is indicated is declared, if it has not already been declared in the block it is in and if it

is a simple name. (Explicit declarations of qualified and/or quantified names will presumably be found elsewhere in the program so they will not be declared contextually.) When an explicit declaration is found, all of the contained information is extracted from it and entered in the tables, possibly adding to or replacing information from previous contextual declarations.

The tables built up by the declaration pass and passed on to the compilation pass are the following:

(a) An attribute table with an entry for each distinguishable programmer-specified name, giving the name's attributes (except those attributes given in other tables, which are only referenced here) and information concerning the structure it is in (if any). This is the main table.

(b) A dimension table, referred to by the attribute table for each array name, giving the dimensions of all arrays. This table is also used to store the values which a label variable can take on if those values are given in a LABEL attribute.

(c) A picture table, containing the information given in PICTURE attributes.

(d) An initialization table, containing the information given in INITIAL attributes.

(e) An identifier table, used for finding the entry in the attribute table for any given identifier in any given block of the program.

(f) A block list giving the block structure of the program and pointing to the names declared in each block.

(g) A statement type table, indicating for each statement in the program whether it is an assignment statement or not.

In addition to building up tables, the declaration pass also makes some changes in the program string in order to facilitate the compilation pass. The four types of changes made are as follows:

(a) All DECLARE statements are deleted from the program string. Also the attribute sections of PROCEDURE and ENTRY statements are deleted. No information is lost since it is retained in the above tables.

(b) A statement number is inserted immediately after each semi-colon which terminates a statement.

(c) In each ON statement if an on-unit is present then a semi-colon and statement number are inserted before the on-unit.

(d) In each IF statement the word THEN is deleted and a semi-colon and statement number are inserted at that point.

As only part of the syntax is checked in the declaration pass, it is not possible to accomplish much error detection and correction during this phase. The syntax of DECLARE statements, the block structure, and the basic structure of many statements are checked. Most of the detailed syntax checking however, is left for the compilation pass.

The syntax is expressed in what are basically Floyd productions, but in a form using several additions intended to make the productions easier to write and faster in execution. The extensions include the following:

(a) Names may be given to classes of terminal symbols (metaclasses), and then when one of these names appears in a production any of the members of the appropriate class will satisfy it.

(b) The next symbol in the input string may be looked at in a production (without pushing it into the stack).

(c) The number of one syntatic rule may be specified in each production. If a rule is specified then the corresponding rule routine (written by the writer of the productions) returning the value TRUE becomes an additional condition which must be met in determining the applicability of the production. This is useful for such things as checking identifier types.

(d) The value of one specified variable may be pushed into the stack by the productions by using the symbol @ in R1, R2, or R3.

In the declaration pass the program string to be passed on to the compilation pass is built up in the main stack with its first symbol at the bottom of the stack. It must therefore be (conceptually) moved to the input area before the compilation pass. The compilation pass will then go through the program string recognizing units such as complex names, expressions, statements, groups, and blocks, and assembling object code to accomplish the execution of the program.

J. Engle

4.4.5 Association Storing Processor (ASP) for Pattern Recognition Purposes

Savitt, Love and Troop (of Hughes Aircraft) recently proposed a form of digital computer in which all programs and data are represented as graph structures. In a paper presented at the Illinois Computer Graphics Conference, McCormick has shown that this type of associative processor may be useful in the processing of certain forms of pictures.

To further explore these possibilities, an ASP simulator is being programmed for the IBM 360, using PL/1 as the intermediate language. Savitt, Love and Troop's language is powerful enough for pattern recognition work, but their processor design is not capable of implementing the entire language. Therefore, additions and changes are being made to implement the entire language.

A preliminary simulator with enough power for a preliminary investigation of pattern recognition problems is expected in February of 1968. No attempt at code optimization has been made in this first exploratory simulator.

J. Fornango

4.5 Library Automation

4.5.1 LEFT: Language for Editing and Formatting Text

Introduction

An entering document is scanned and stripped of its typographical description according to the analysis language and is converted to an intermediate form. Alternatively the intermediate form may be inputted directly by a user at a console. The intermediate form is first parsed according to a set of Floyd productions and code for text reformatting outputted as specified by the executes of the FPL. By varying the executes, various style manuals can be defined.

This language embodies a complete distinction between the medium-independent structure of text and the purely typographical or packaging description of text.

In general, text can be specified in terms of a major structure (document) which can, in turn be expressed in terms of minor structures (table of contents, index, bibliography, etc.). Some minor structures, e.g. bibliography have been defined by a context-free grammar and similar grammars for the remainder are being explored.

Definition of the Language

It is convenient to think of an item of text, e.g. a bibliography, as being written in a sufficiently restricted domain of natural language so as to constitute an artificial, or programming, language. The syntactic and semantic descriptions of the text language will be accepted by a universal translator to produce a translator to be run on Illiac III for the text language. By means of the universal translator, future modifications to the syntactical descriptions of the minor structures can be readily incorporated. For implementation, Floyd productions are being written from the BNF syntactic description of the minor structures. Later, a semantic description will be given (in the Language for Editing and Formatting Text: LEFT). The executes in the Floyd Productions Language (FPL) can be considered as not only generating code for the grammatically recognized constructs (parsing and recognition are controlled by tables generated from the syntax loader) but also as specifying typographical

instructions for the eventual format (from the executes defining LEFT - language code generation). In this way, choice of style manual may be implemented by merely changing the executes in the FPL.

For a particular document, the text structure (TE) and the typographical structure (TY) can be represented by epimorphic tree structures such that TE → TY. Items of text can occur only at terminal nodes in TE, whereas in TY, format commands may occur at any node, thus giving rise to a form of block structure. Format commands occuring at same node in TY will apply directly to (i) any data held by the inverse image node in TE (ii) any data held in nodes subsumed by the inverse image, if the original format commands are not overruled by subsequently encountered commands.

Use of the Language

The input can be considered either (1) a character string where character recognition has been done directly from the input text image or alternatively (2) generated line-by-line in a syntax-directed dialog mode by the user at a console. The parsed item of text will then be displayed according to a selected program from the style-manual library.

S. Flowerdew

4.5.2 Search Language

The ISL programming language had been totally rewritten using the ILLAR assembly system in development at the Coordinated Science Laboratory during the summer of this year. In the early fall we were still cleaning up small problems concerned with the rewriting in a new system. These problems seem to have all been resolved.

Work was begun in late summer and continuing through the fall on an interactive system to enable a user to initiate certain search requests directly from the console typewriter. The result is a program (or set of programs) called REQUEST. The user at the console can enter a query in two forms.

The first of these is a parenthesized statement of the search to be made. This option requires the user to be rather familiar with the structure of the data collection, but enables him without actually writing a program to ask at the typewriter for the more typical kinds of searches he would normally want.

The second form of input of a query is easier to use effectively than the parenthesized form. Upon entry to the program the typewriter gives the signal "State your request". At this point the user may enter a Boolean product of sums, the elements of which are variables to indicate the user's information requirements: at this point, information about a source article or a citation article or some combination of these. When this level is complete the program scans the variables used and asks for definition of the source or citation variables in terms of item variables. These are entered in the same way as in the first level, with the user typing what he wants. As he types, the entire discourse is displayed on the scope to give a complete record of questions asked by the program and responses by the user. When all the source or citation variables have been defined, the REQUEST program then scans the item variables and asks for their definition. These also are a product of statements but now the elements are actually character strings for which the search is required. These strings may include the "don't care" character. When the item variables have all been defined the search is ready to be made.

At this point the user can get a printed or photographic record of his request, go back and reformulate the request, or exit the entire routine. Assuming that he is satisfied with the formulation of his request the user then types "search".

The data collection on magnetic tape is searched for all records (documents) that satisfy the request. When one is found it is immediately displayed for the user's inspection. He may then get a printed copy of the document or write it on a separate magnetic tape for later use. When the user has finished inspection of the current document he may exit the system, formulate another query or continue searching for more documents satisfying his present query.

The package of routines to copy, list, translate from fixed field length records, pack the data and check the syntax of the data are all complete and being used. Routines have been written and used to do a keyword-in-context of the titles in the data collection. The sort program from Control Data Corp. is not actually in the ISL system yet but it is in a form useable to us. Some experience is being gained in programs to assign ascension numbers to documents in such a way that documents which are the same are assigned the same ascension number. Work is under way, using the ISL programming language (or, more accurately, system) to investigate clustering of citation graphs and key-words.

K. Kelley

4.6 Outline of Illiac III Computer System

The section numbers of the outline below correspond to section headings of this Progress Report.

4.7 Central System

- 4.7.1 Taxicrinic Processors
- 4.7.2 Fast Core Storage Modules
- 4.7.3 Arithmetic Units
- 4.7.4 Interrupt Unit
- 4.7.5 Pattern Articulation Unit
- 4.7.6 Exchange Net
- 4.7.7 Status of the Main Frame Assembly

4.8 I/O System

- 4.8.1 I/O Processors
- 4.8.2 Channel Interface Units

4.9 Peripheral System

- 4.9.1 Secondary Storage System
    - 4.9.1.1 Magnetic Tape System
- 4.9.2 Scan/Display System
    - 4.9.2.1 Scan/Display Controllers
    - 4.9.2.2 Scanner/Monitor Center
    - 4.9.2.3 Scan Converters
    - 4.9.2.4 Video Communications Net
    - 4.9.2.5 Videograph Printer
    - 4.9.2.6 Remote Video Consoles
    - 4.9.2.7 Video Storage
    - 4.9.2.8 Microimage Storage
    - 4.9.2.9 Specifications for the Microfiche/Ultrafiche Library
- 4.9.3 Intermachine Link to Illinet (IBM 360)

4.9.4 Low Speed Terminal Network

4.9.4.1 Low Speed Communications Net

4.9.4.2 Low Speed Buffers

4.9.4.3 Low Speed Terminals

4.9.4.3.1 Monitor Selective Typewriters (5)

4.9.4.3.2 Monitor Magnetic Tape Module (5)

4.9.4.3.3 Mod 33 ASR Teletype Sets

4.9.4.3.4 Analog Instruments

4.10 Power Distribution

4.10.1 Primary DC Power Supplies

4.10.2 Power Distribution System

4.10.3 AC Power Distribution System

4.11 Unassigned Equipment Pool

4.11.1 Circuit Card Inventory

4.11.2 Test Equipment Additions: Commercial

4.11.3 Test Equipment Additions: Custom-design

4.12 Documentation

4.12.1 Engineering Manual

4.12.2 Circuit Books

4.12.3 Logic Book

4.12.4 Wiring Tables

4.12.5 Opto/Mech. Design

4.13 Circuit Research and Development

4.13.1 Card Testing

4.13.2 Other

4.7 Central System

4.7.1 Taxicrinic Processors

4.7.1.1 Logic Design

The main effort this quarter was directed toward improving the imprimitive instruction control sequence. These four instructions were considerably simplified and re-flowcharted. At this time they seem to be fairly compact but they are still not completely esthetically pleasing.

Work was also done on the control sequences for pre-and post-operations on operand phrases. These operation sequences are now completely specified.

A new instruction was added, ASSIGN. This instruction is a generalized data transfer from register to core, register to register, core to core,or core to register. It will replace several of the old instructions as well as adding new capabilities not present before.

Work was begun on the design of the control logic. Little progress has been made to date, but general control design techniques are in the process of being developed.

4.7.1.2 Documentation

The rough draft of the Taxicrinic Processor Manual is currently being edited so that it can be published as a DCL technical report.

The IBM card file of all the signal names in the Taxicrinic Processor is currently being updated to include more information about each signal. This will involve a complete repunching of the file.

4.7.1.3 Hardware and Wiring

No progress - but no regression either.

B. Nordmann

4.7.2 Fast Core Storage Units

The first of two fast core memories was in the first phase of final acceptance tests at the Fabritek plant during the week of February 12, 1968. It is anticipated that these tests (thermal cycling forth 8 hour error-free run) will be completed to the satisfaction of our observer during the week of February 19th after which the memory unit will be shipped. The second unit is expected to follow the first in one month.

S. Ray

4.7.3 Arithmetic Units

The design of the arithmetic units has progressed well during the past quarter. Advances have been made in both the area of detailed logical design and in the simulation of structure and control.

4.7.3.1 Logical Design

Near the beginning of this quarter it was realized that a new card type was desirable for use in the arithmetic units. This card, now designated the 1018-294-00, contains eight bit positions of an ADD-OR selector as shown in Figure 4.7.3.1.1.

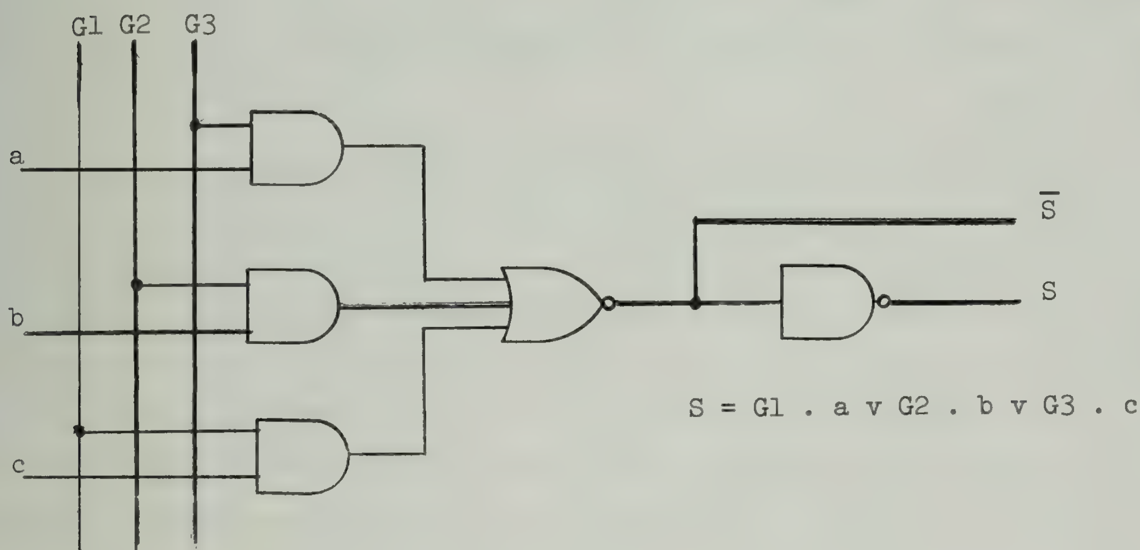

Figure 4.7.3.1.1 - One Position of Selector Card - 1018-294-00

The major advantages of this card over the similar 6-position, 235 card are the savings in cards (40 per AU) and the convenience of 8 bits (one data byte) per card. The card does, however, demand a high component density.

This 294 card has now been adopted for use as the input selectors to the main registers and for the shift-array coupling the Multiplier Register to the Adder/Subtractors. This change required the redrawing of some previous logic diagrams, but all modifications have now been completed by L. L. Byers. "Sepia" print templates are now being used to minimize repetitive drawing.

The detailed logic drawings of all registers, data transfer paths, and major functional blocks of the AU structure, as distinguished from control, are now two-thirds complete and will be completed and largely checked within the next two months. Packaging specifications, although now begun, will then be emphasized.

In connection with the logical design of the control of the AU's and other units of Illiac III, a team of engineers has begun specifying special control cards. The detailed specification of control logic remains the prime logical design task in the completion of the arithmetic units.

4.7.3.2 Control

Simulation is the main tool being used in the specification of control sequencing and the verification of the execution algorithms. Stimulated by success with earlier partial simulations using MAD and faced with the pending obsolescence of these programs with the loss of the IBM 7094, it was decided to produce a new simulation written in PL/1. During this quarter the structure of an AU was coded and to date the operation of floating addition, subtraction and compare have been fully simulated and verified and multiplication is well underway. Division will be included next and then the integer operations and conversion instructions. The flowcharts necessary for the simulation together with the actual PL/1 code will provide the basis for the logical design of the control. The simulation conducted to date has been very reassuring and also useful in refining the control algorithms. It also provides dynamic documentation and will eventually be used for the training of maintenance personnel and for the generation of maintenance routines.

D. Atkins

4.7.4 Interrupt Unit

The initiation, testing and termination of input/output processes uses the interrupt unit as a communications link. These commands have been simplified and formally described in the programming manual.

No additional progress was made this quarter, awaiting decision of the I/O interrupt command specification.

4.7.5 Pattern Articulation Unit

The order code of the Pattern Articulation Unit has been written in a final form, and is ready for distribution with the programming manual. During the last quarter the proposed form for the PAU control was investigated. The control will be microprogrammed using diodes as a read-only memory. The exact details have yet to be worked out.

It has been decided to simulate the PAU (in PL/1) at the gate level in order to check the control design. It is anticipated that this simulator will be the first version to be used in the Illiac III simulator.

The first of two reports on the BØØLE instruction has been published: DCS Report No. 253, "The Pattern Articulation Unit of Illiac III: Homogeneous Boolean Functions in the Iterative Array" by B. McCormick, W. Watson, R. Borovec. Work on the second continues.

In the hardware area, the wiring lists for the Iterative Array and the Transfer Memory have been completed and the units are ready for wiring by an outside vendor. The wiring for the display system has not yet been completed.

R. Borovec

4.7.6 Exchange Net

1. All changes resulting from the checking of logic, circuit compatibility, timing and power requirements are complete.

2. Printed circuit board layout of the Exchange Net logic is complete.

3. Details (pin, board and rack reference numbers) are being added to the logical drawings.

4. The problems associated with the routing of cables between the Exchange, Processors, and Units have been resolved. Also an option has been provided such that half or full duplexing of data lines of the Processor-Exchange, Unit-Exchange interfaces is possible. Half duplexing of data lines at these interfaces will decrease the number of cables needed by 40% (from 2400 to 1440).

4.7.7 Status of the Main Frame Assembly

1. Fabrication of 2 additional wings has been started.

2. Fabrication of 28 power bus bars for 2 new wings has been started.

3. Material ordered for 8 end plates (for card racks of new wings).

4. Fabrication of 48 card rack retaining rods complete (for card racks at new wings).

5. Modification (milling) of 78 existing power bus bars complete (modified to accept AMP power bus strips).

6. Drawings completed for the assembly of modine bars.

7. Fabrication of 28 power bus bars completed for the Exchange Net.

8. Started scale drawings of Illiac III area (Rooms 217, 223 and 280). These drawings will be used for specifying the additional false floor proposed in the last quarterly report.

9. Received 2500 printed circuit board connectors from AMP. Installation at these connectors in the mainframe has started.

10. Received the tooling and 300,000 Termi-Point clips from AMP. (100,000 ft. of wire on order). Reception of this hardware allows us to begin the mainframe wiring of logic.

P. Krabbe

4.8 I/O System

4.8.1 I/O Processors

Preliminary results of the IOP simulation, discussed in Section 4.4.1.3, confirm the workability and logic of operation of the IOP Program Registers as described by Cederquist and Hayes. The simulation also indicated the need for one modification in the Program Register organization and several modifications of the command operations.

The register reorganization consists simply of associating the data pointer registers with channels rather than with programs. This should facilitate the programming of multiple-channel operations (controlling two or more devices on different channels with one I/O program).

The command modifications consist mostly of channel and memory protection methods which, although simpler, are more effective than the previous ones. For instance, the program key, that determines which channels may be used by which program, may not be modified from within a program. Similarly, a base register or base resister name cannot be modified from within a program. These modifications can only be made by the supervisor with START IO or MODIFY IO.

Future results of the IOP simulation will probably continue to alter the IOP design although in an increasingly minor way. It is more likely that future results will further define those parts of the IOP design that are not yet complete.

L. Katoh

4.8.2 Channel Interface Units

The register arrangement of the Channel Interface Unit was settled in the summer 1967. During the latter half of this quarter work has been done on specifying the control logic.

The CIU control logic is divided into the following sections:

IOP-CIU control lines
CIU-CU control lines
BCOUNT/ZCOUNT registers
Data byte counter (Mod. 8)
Data buffer register selection logic
Miscellaneous registers

Almost all sections listed above have been specified; they are being added to the preliminary CIU manual which was written during the last quarter.

Hardware design of the CIU control logic was partially done in the summer 1967. The remainder will be finished at the early part of the next quarter. The CIU operation flow charts written in the 1966-67 academic year and the control logic specifications written in this quarter serve as a basis for the control logic design.

S. Hiroe

4.9 Peripheral System

4.9.1 Secondary Storage System

No advance was made during this quarter, as consistent with the lack of funds.

4.9.2 Scan/Display System

4.9.2.1 Scan/Display Controllers

About 60% of the digital logic for one scanner (excluding control) has been wired and is presently undergoing test. The functions that have been wired include:

a) Gross and vernier position counters and local counter control.

b) All input registers associated with the counters.

c) Equality circuits for the counters.

d) Output cable drivers and associated buffers.

Functions presently under design include:

a) Gray scale input/output

b) Incremental mode decoder

c) Slit angle control

Many design changes have been made to reflect new definitions and/or simpler design; e.g., the output of the vernier counters will be used to obtain the beam translation needed for hexagonal and/or interlace operation. Several of these design changes which affect the existing wiring have yet to be implemented. These wiring changes should be completed by the end of February.

The modes of data transmission between the scanners, monitors and the video communication net has forced an extensive re-examination of the scanner control logic. At this time these intercommunication problems appear resolved.

Preliminary flow charts for the control of coordinate and raster modes of operation have been drawn per the specifications in the Scanner/Monitor Manual (of Section 4.3.2). Preliminary flow charts for the revised video/display operation are currently being drawn.

L. Goyal, V. Tareski

4.9.2.2 Scanner/Monitor Center

4.9.2.2.1 Monitor Fabrication

All monitors have been modified to accept the new Litton yoke mounts. Much of the remaining installation has been completed including installation of deflection amplifier frames, power supplies, DAC trays, logic drawers and handwheels. All power amplifiers and preamps have been built and approximately half have been tested. Monitor number four has all analog and power circuits installed and tested including DAC logic, high voltage supplies, local DC regulator and AC turn-on system.

4.9.2.2.2 Monitor Checkout

Checkout of monitor number four has revealed that spot size is acceptable, amplifier performance is good, but that some form of phosphor protection will be required and that faster digital-to-analog conversion is needed. The twelve bit double rank look-ahead counters operate satisfactorily at rates up to 4 MHZ.

4.9.2.2.3 Scanner Fabrication

Most of the installation of power supplies, amplifier frames and similar items have been completed in the scanners. The 70 mm. scanner has all power supplies, amplifiers, the remote yoke adjustment system, optics and one photomultiplier tube.

4.9.2.2.4 Scanner Checkout

A temporary DAC system has been installed in the 70 mm. scanner to aid in the checkout of the CRT deflection system and the photomultipliers. Preliminary tests show that the spot can be "snapped" across the width of the CRT face in approximately 10 μsec. Tests of spot size, phosphor response time and photomultiplier circuitry are continuing.

J. L. Divilbiss
D. Foster

4.9.2.2.5 Microfiche Scanners

Two microfiche transport mechanisms will be installed in the 35 mm. scanners of Illiac III. One unit will scan an input microfiche for research on automated text analysis. The second unit will photograph output in the form of edited documents.

COSATI* standard fiche will be used. The form we have settled upon consists of a 4x6 inch sheet of film carrying 72 page images in a 6x12 matrix. A minimum resolution of 127 lines per millimeter is specified.

We have on hand two microfiche transport mechanisms (Bell & Howell) which will require engineering adaptation to operate in the scanners. Control logic, transfer optics, film clamping and pick-up optics will be designed such that the units will meet or exceed the quality standards COSATI has set. While a great deal of engineering effort thas been saved by the purchase of the basic x-y transports, considerable design and construction remains to be done in order to allow installation and operation of the units. This was anticipated and the work is proceeding.

R. Amendola

*COSATI - Committee on Scientific and Technical Information

4.9.2.3 Scan Converters

No advance was made during this quarter, as consistent with the lack of funds.

4.9.2.4 Video Communications Net

No advance was made this quarter, other than contract discussions with Ampex to resolve technical questions arising from our contract with them.

4.9.2.5 Videograph Printer

This unit has been received, uncrated and moved into its permanent position. Main AC power connections to the equipment and auxiliary outlets are complete.

Installation of 810 cu.ft./min. auxiliary blower and venting system was completed by the University Physical Plant in December. Temporary connections between the printer and venting system was completed in December. Checkout of the venting system is complete. Permanent connection of the printer to the venting system now requires approximately 8 man hours. Completion consists of routing the flexible duct under the false floor in Room 217.

The A. B. Dick Co. sent a crew to make final adjustments and installation checks. The check-out crew, consisting of Frank Huffman, Robert Carlson and Jerry Donahue of A. B. Dick Corp., was originally scheduled to arrive the third of January 1968. However, severe weather conditions forced postponement of their trip until January 8, 1968. Completion of installation and check-out required three days. The unit is perhaps 89% acceptable at this point. Mr. Carlson has promised to fabricate and send us certain critical nylon parts. These will replace metal parts which are believed responsible for excess mechanical vibration. This vibration degraded the horizontal resolution achievable from the printer.

Received from A. B. Dick,along with the printer are three complete sets of electrical, electronic, and logic drawings; one complete set of mechanical assembly drawings; small quantity of spare paper drive belts; odds and ends of solid state components, unique gauges and hardware.

Current supplies of paper, developer and toner seem to exceed (at present rate of consumption) at least one month's requirements.

J. V. Wenta

4.9.2.6 Remote Video Console Design

Considerable design study has been completed on the remote terminals for Illiac III. A major limitation on the final design of the console proper has been the lack of dimensional information on the monitor chassis to be included. Since the monitor chassis design has been set by the manufacturer, it is now possible to set the final dimensions, complete the console design, and have the units constructed.

The basic visual devices consist of two 17-inch television-type tubes (one for fast scan, one for slow) and a microfiche viewer set side-by-side of a convenient angle for viewing. The console will have a desk space and an I/O patch panel plus cursor control. The console itself will be entirely self-contained and movable; the only other units associated with the console will be the teletype and (optionally) a cable-connected television camera.

Final design and construction can now take place as most of the engineering constraints have been established.

4.9.2.7 Video Storage

No progress has been made during the past quarter.

4.9.2.8 Microimage Storage

A very high density photographic data storage system is being designed for the Illiac III video communications network. Document pages initially 8.5x11 inches will be reduced 162:1 onto a film base at high packing densities and the resulting film sheets accessed by a high speed retrieval mechanism. The selected image will then be flashed into a high resolution vidicon camera (currently under contract) for presentation as a graphic image to Illiac III or to a remote viewer.

An ultimate storage goal of 5×10^7 pages or about 10^5 books (each 500 pages) is possible, but an access time of <10 seconds is also highly desirable. This reduced access time requires a great deal of engineering work as any resultant device must have very high reliability.

Consequently, a prototype slow, limited-number-of pages device will be used to explore system design and engineering requirements. This prototype will consist of a modified commercially available viewer which handles and projects a single frame from an image matrix on a 4x5 inch film sheet. High photographic quality is achieved by holding a resolution of at least 500 optical lines per millimeter; this is somewhat in excess of that necessary for use by the high resolution video cameras and network Illiac III. The projected image will be thrown both onto a viewing screen associated with the viewer itself and onto the active area of a vidicon camera.

The prototype film sheet will have a 64x64 array of images (some frames will be blank) of test documents for checks on system image quality when looking at various type fonts, continuous tone photographs, and sample resolution charts. From these tests, the design group will be able to set further video and optical system parameters and study the design of the very large storage and retrieval system.

A test image format is being designed, and engineering modifications to the commercial access mechanism and viewer to accommodate the television camera are being decided upon. A single chip will be used in the viewer, but the platen will be modified to accept both protective laminated standard chips and experimental unprotected sheets slated for later development. 4096 image locations on a 4x5 inch chip will be available.

4.9.2.9 Microfiche Library

An extensive microfiche library will be produced at the Illiac III facility. This will consist of a wide range of materials including scientific and technical documents, reports and material for text analysis.

All of the equipment required for the production of very high quality microfiche is on hand. This includes a microfiche camera, a versatile film processor, diazo duplication equipment, and other ancillary supplies. At this point the microfiche facility is ready to begin production; however, a pending change of location will cause some delay.

There remain the details of designing the actual forms of entry for documents, i.e., number identification series, classification, coding, priorities, and scheduling. Now that the facility is ready for production runs, we are ready to collect representative documents and set standards.

Filming rates should exceed 500 pages per hour including identification and film processing, but not including diazo duplication which operates on a card-by-card basis.

R. Amendola

4.9.3 Intermachine Link to Illinet (IBM 360-50)

No further design other than the parallel design for the Channel Interface Units was completed this quarter.

4.9.4 Low Speed Terminal Network

4.9.4.1 Low Speed Communication Net

See previous quarterly progress report.

4.9.4.2 Low Speed Buffers

The design of this system has been completed and has been divided into two major groups.

1. Low Speed Buffer Control - A prototype of this control is about 25% complete and will be tested with a local teletype unit. The first draft of the control documentation is complete.

2. Buffer Memory - This unit is completely wired with the exception of a few termination drivers and will be ready for testing in the near future. The first draft of the documentation for this unit is finished.

4.9.4.3 Low Speed Terminals

4.9.4.3.1 Monitor Selective Typewriters (5)

The Selectric typewriters will be wired into the monitors to provide hard copy I/O functions.

4.9.4.3.2 Monitor Magnetic Tape Modules (5)

These units have been installed into the monitors but have not been tested due to the elaborate testing apparatus required.

4.9.4.3.3 Mod. 33 ASR Teletype Sets

There are five units available for use as remote I/O to Illiac III. At present, one of these Mod. 33 ASR teletype sets is in a time sharing net with Illiac II and will be used for both engineering and inventory operations.

4.9.4.3.4 Analog Instruments

There is only a token amount of design completed in this area due to prior design commitments.

R. Martin

4.10 Power Distribution

The design of this system is approximately 95% complete, but the fabrication and final assembly is only 30% complete. The status of the various sub-systems is as follows:

4.10.1 Primary D.C. Power Supplies

A considerable number of power supplies are still inoperative, due to the damage sustained by the fire last March, and will require rigorous trouble-shooting and dynamic testing procedures to insure that these supplies will render reliable service.

While it is evident that additional primary supplies will be needed as future load current requirements are realized, initial sections of the machine will be adequately supplied by the units now on hand.

About 60% of the primary distribution cable is laid but has not been connected. Routing of the remaining cable will depend on the current requirements in Rooms 280 and 223.

4.10.2 Power Distribution System

4.10.2.1 Primary D.C. Distribution Center (Room 223)

The design of this Distribution Center is about 80% complete and various modules and sub-assemblies are being fabricated. The line relay modules are being assembled and will be installed on the wall in Room 223 in the near future. The modification of the distribution framework and the relocation of the card racks are now under consideration. The cable-connectors and signal distribution rack specifications are being revaluated and the final requirements should be known by the first month of the new quarter.

4.10.2.2 Primary D.C. Distribution (Room 280)

The DC grounding bar has been laid in Room 280 and the distribution rack has been completed but has not been installed. As soon as the current-load requirements are known, cables connecting the distribution rack and the various pieces of equipment can be laid.

4.10.2.3 Secondary D.C. Distribution

This wire for secondary distribution has been ordered but no installation has been started. The modine regulator channels have been completed and wiring and installation into the mainframe is scheduled to start soon. The capacitors will also be assembled into the mainframe in the near future.

4.10.2.4 Control of Power Distribution Systems

Power Turnon and Protection - The design of this section is complete but no wiring has been done. About 70% of the required printed circuit cards are in stock and the remaining 30% have been ordered. Both the intermediate connectors and cables, which connect the mainframe to the protection system, have not been ordered but their general requirements are now being investigated.

Local Power Regulation Boxes - These boxes have been fabricated and are being tested prior to their installation into the machine.

A.C. Turnon Boxes - These boxes have been fabricated and about 50% of these units have been tested and installed into the machine.

4.10.3 A.C. Power Distribution

The A.C. distribution system is complete and appears to handle all our present load requirements.

R. Martin

4.11 Unassigned Equipment Pool

4.11.1 Circuit Card Inventory

Some 440 more Printed Circuit Boards have been completed and added to the inventory.

Basic data concerning the initial group of Printed Circuit Boards (about 10,500) was punched up on tab cards with a borrowed keypunch, Model 26. We now have on order a Model 29 keypunch for the Illiac III area. This will enable us to complete initial entries for all Printed Circuit Boards as they are completed, and will also facilitate the program of continual updating of testing and repair data as it is generated.

T. Kingery

4.11.2 Test Equipment Additions: Commercial

Purchases in this quarter were confined to a Shallcross 6862 precision resistance decade, a DC current probe (for measuring yoke currents), a high voltage probe (for CRT second anode voltage measurements) and assorted accessories and repair parts.

D. Foster

4.11.3 Test Equipment Additions: Custom-Design

No significant additions this quarter.

4.12 Documentation

4.12.1 Engineering Manual

Updated, but no significant change from last quarter.

4.12.2 Circuit Book

Circuit books have been maintained to date. Work was completed for eight circuits and eighteen engineering changes.

4.12.3 Logic Book

Interim drafting of logic diagrams for the exchange unit is near completion. Logic design for the scanner monitors, channel interface units, low speed buffer and arithmetic units have progressed closer to the intermediate drafting stage.

4.12.4 Wiring Tables

Wiring tables for the scanners and the exchange net are in preparation.

4.12.5 Opto/Mechanical Design

From October 1, 1967, through January 10, 1968, 18 new detail and assembly drawings have been made.

Twenty-two (22) additional drawings have been processed according to engineering change orders due to modifications and improvements in opto-mechanical design.

Ten (10) work orders have been placed with our machine shop.

4.13 Circuit Research and Development

4.13.1 Card Testing

The threshold tester, described in the previous report, has been built and checked. To facilitate the testing of many different types of cards, the tester incorporates a novel 48x58 switch matrix which can be set easily.

4.13.2 Other Circuit Developments

An analog dynamic focus correction circuit, requiring only five transistors, has been developed. This circuit uses voltages available from the deflection amplifiers to form a signal proportional to the square of the deflection distance away from center screen. If a correction function, other than $f = k(X^2+Y^2)$, proves more satisfactory, the circuit can be modified easily.

J. Divilbiss
S. Franco

4.14 Bibliography

During the quarter the following File Numbers and Reports have been issued:

File Numbers

File No. 741 "Advances in the Development of Image Processing Hardware" by B. H. McCormick, October 20, 1967.

Reports

Report No. 253 "The Pattern Articulation Unit of Illiac III: Homogeneous Boolean Functions in the Iterative Array" by B. H. McCormick, W. J. Watson, R. T. Borovec, January 8, 1968.

4.15 Illiac III Staff[1]

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Dr. Robert M. Lansford - Research Associate
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[1] Not including hourly employees
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5. ILLIAC IV

(This work was supported in part by the Department of Computer Science, University of Illinois, Urbana, Illinois, and in part by the Advanced Research Projects Agency as administered by the Rome Air Development Center, under Contract No. US AF 30(602)4144.)

REPORT SUMMARY

Burroughs has executed its subcontract with Texas Instruments. The terms mirror precisely the terms in the contract between the University of Illinois and Burroughs.

The PE design is complete. However, implementation will be delayed by several months due to noise problems that have emerged with the 64 pin packages. It is hoped that the 64 pin packages (possibly expanded to 84 pins to permit providing a separate voltage supply to each gate group) will prove acceptable for the PE. It may be necessary to retreat to conventional IC's (14 or 16 pin dual inline packages) in the CU and PE memory. These considerations impact schedule and performance and have made it impossible to complete our rescheduling efforts during this quarter. It appears certain now, however, that during the next calendar quarter, successful progress can be made to predict accurately the impact on cost, schedule, and specifications.

The overall system design is now complete with the exception of the IOC. This report contains descriptions of configuration control, interrupt control, and the degree of synchronism between quadrants. The diagnostic programming effort has been initiated during this quarter, and it is expected that a preliminary detailed schedule of this task will be available at the end of the first quarter of 1969.

Work on the translator writer system and source language system continue on schedule. A unified approach to many problems in partial differential equations has been initiated and is outlined in this report. It is felt that this is a particularly important application effort, and future progress reports will contain summaries of progress as the work develops. In this effort, the help of many people in the community interested in large mesh calculations is being enlisted to achieve a useful definition of this system of programs.

5.1 System Design

5.1.1 Introduction

During this period the multiprocessing capability of ILLIAC IV received attention for the system design activity. The activity includes the definition of configuration control, interrupt control, and I/O data transfer control.

5.1.2 Configuration Control

Three, 4-bit configuration control registers (CFCO, CFC1, CFC2) are employed for each CU. Each bit in a CFC corresponds to one CU. CFCO defines a set of CU's which execute the same stream of instructions. CFC1 defines the array or arrays into which the instructions are loaded. CFC2 defines the array or arrays into which data for CU instructions are loaded.

CFCO should specify one, two, or four CU's, one of them being its own CU. CFC1 and 2 can have any subset of the CU's specified by CFCO.

A concept of local and global CU instructions, which can be discriminated by a bit in the instruction, was adopted for simplicity. When the bit is zero (local instruction), the configuration control is bypassed and executed immediately in the CU; when the bit is one (global instruction), synchronization of the CU's specified by one of CFC's is requested before the execution of the instructions.

5.1.3 Interrupt Control

CU's handle interrupts individually in its own CU. This is due to a CU's non-synchronized operation, and most interrupts are local to each CU.

One of eight instruction buffer blocks is reserved for an interrupt handling routine; so as to hold the contents of the instruction buffer during the execution of the routine.

5.1.4 Input/Output

Software and hardware control over the whole I/O process is now being discussed. Some desired features have been identified and these are: 1) size of a data block and addressing and 2) memory for a queue of interrupts. Sixteen word data block and models of sixteen addressing registers have been suggested to handle small matrices and data descriptions. A memory for an interrupt queue is needed because one B6500 multiplier handles five different I/O's, namely DISK and four CU's. A part of the B6500 memory can be used for this purpose.

5.2 Diagnostic Programming

There are two efforts directed at developing algorithms for diagnostic programs. The first effort is to develop a computer program for checking data paths within ILLIAC IV. Data is input to the program in the form of a specification of the computer which includes a list of the component units and their connectivity and the constraints imposed by the machines' order code. For designated input-output combinations, the program will produce sequences of machine instructions that activate all possible paths from the input to the output. These sequences can then be used for fault testing. This program has been written and is in the process of checkout.

The second effort is to develop methods of checking LSI chips. The approach is to define input/output pins and to develop a minimal sequence of input patterns which will test all of the externally testable function on the chip. This method has been applied to the Carry-Save Adder (ILLIAC IV Doc. No. 160)[1], and a set of 107 test patterns for a PE exerciser unit has been determined. A set of 872 test patterns that can be implemented using the PE multiply operation has also been derived.

Burroughs has been informed of these efforts and will coordinate their fault diagnosis efforts with these.

5.3 Language Translator Writing System (TWS)

5.3.1 Introduction

The functional parts of the TWS were described in the last Quarterly Progress Report. The paragraphs below outline the progress in implementing the system.

5.3.2 Syntax Preprocessor

The syntax preprocessor which was designed and coded is being debugged. It scans the BNF productions in the syntactic metalanguage which specifies the syntax of a programming language (L) and generates a table of special terminal symbols, a table of nonterminal symbols, and a table which represents the productions. The first table will be used by the source program symbol scanner of the compiler for L to recognize either special terminal symbols or reserved words. The second table is, at the moment, discarded after a successful compiler has been generated. The third table is scanned by a procedure which attempts to convert it to Floyd Production Language form. Debugging is about to begin on this procedure, which is an implementation of the conversion algorithm described last quarter. Test of this algorithm on an unambiguous version of ALGOL 60 needed at most a two symbol lookahead. The output is a set of Floyd productions in the form of a sequence of pseudo orders which will be interpreted by a recognizer to parse a program in language L.

5.3.3 Symbol Scanner

The symbol scanner, which recognizes basic syntactic entities including identifiers, strings, literals, reserved words or special symbols, and single character terminals, is now operational. It performs table look up and entry on all but single character terminals. It converts literals, fixed or floating, with or without exponent and variable base which can range in value from 2 to 36, to a 64 bit ILLIAC IV word (the converted form is entered in the table).

A theoretical model has been created which reorders a linear list into a symmetric binary search tree. Its value is that it allows programs of just single character (or string) recognition capability to generate symmetric (structural) tables. The model has been designed to eliminate the need for reordering of data.

5.1.4 Semantics and Intermediate Language

During this quarter, the language in which semantics is going to be specified to the TWS was defined and developed. As described in the previous report, the primary aim was to develop a language embodying the features of Burroughs extended ALGOL (used on the B5500 machine) and some special features to facilitate the description of the semantics of a programming language. Typical of these special features are commands for declaring and manipulating tables and stacks.

Some restrictions of the B5500 ALGOL compiler led to the conclusion that the only practical way of implementing the semantics language was by using a translator rather than direct usage of ALGOL procedures as originally planned. Thus, a language for describing the semantics of programming languages was tentatively defined (syntax and semantics). The language, called Illinois Semantic Language (ISL), is basically an extension of ALGOL; most of Burroughs extended ALGOL is allowed, and some additional commands were added to implement the special features mentioned above. The ISL Translator is an ALGOL program that accepts as input a program written in ISL and translates it into an ALGOL program. The translator is almost completely written, and debugging has been started.

5.4 Tranquil

This quarter marked the beginning of the implementation of the Tranquil compiler using the Translator Writing System.

The syntax specification for the declaration part of Tranquil has been redefined, and it now includes an option for the user to specify the maximum size of a dynamic array. The compiler then may determine an upper bound on likely memory requirements and hence determine the ILLIAC IV quadrant configuration best suited to the problem. The corresponding Pass I semantic routines are also being written.

In considering set declarations, a decision has been made to require the type of set involved to be declared along with other information if the set is dynamic (for storage reasons). This information will be placed in the main Pass I descriptor table; the fields of which have been specified for sets, as well as for arrays, variables, procedures, switches, and labels. Control statement syntax has been further specified, and productions have been linked with Pass I semantic routines for constructing the intermediate language to be analyzed during Pass II of the compiler.

The grammer for expressions was rewritten to the specifications required by the syntax analyzer. The Pass I semantic routines that correspond to these productions primarily involve transferring an operand from the input stack to the intermediate language output stream.

Because of the basically nonparallel nature of much of the work that must be done at the beginning of each block, a scheme has been devised to take partial advantage of ILLIAC IV parallelism by combining many strings or inherently sequential operations into a single, longer string of parallel operations. A program has been written to perform this conversion. This method is fairly good when the number of different operations involved is kept small and when the data bases of each of the different strings of operations are very similar. The criterion seems to be fairly well satisfied by the type of computations required at the beginning of a block.

5.5 Gleipnir

Preliminary specifications for a general purpose list processing language (Gleipnir) were completed in late September. This language is based on L^6 [2] but has an ALGOL-like syntactic structure.

In order to improve its compatibility with Tranquil, a major revision of Gleipnir was completed in December. With this revision, Gleipnir retains the basic philosophy of L^6, but the treatment of variables and procedures is more like conventional ALGOL.

The basic entities of Gleipnir are base registers and field declarations. Base registers may be declared and used analogously to variables in ALGOL (with the exception of arrays). In addition, base registers may be used to hold pointers. Thus, complex data structures can be referenced via intial pointers contained in base registers.

Fields are declared in much the same way as base registers. These field definitions are applied to storage blocks (which are assigned dynamically by the storage allocator) as though one were applying a stencil to each block.

The following example is a procedure which searches a binary tree in each PE, and when a keyword is found, an associated 32 bit quantity is returned. Figure 1 shows how the data is arranged in one PE.

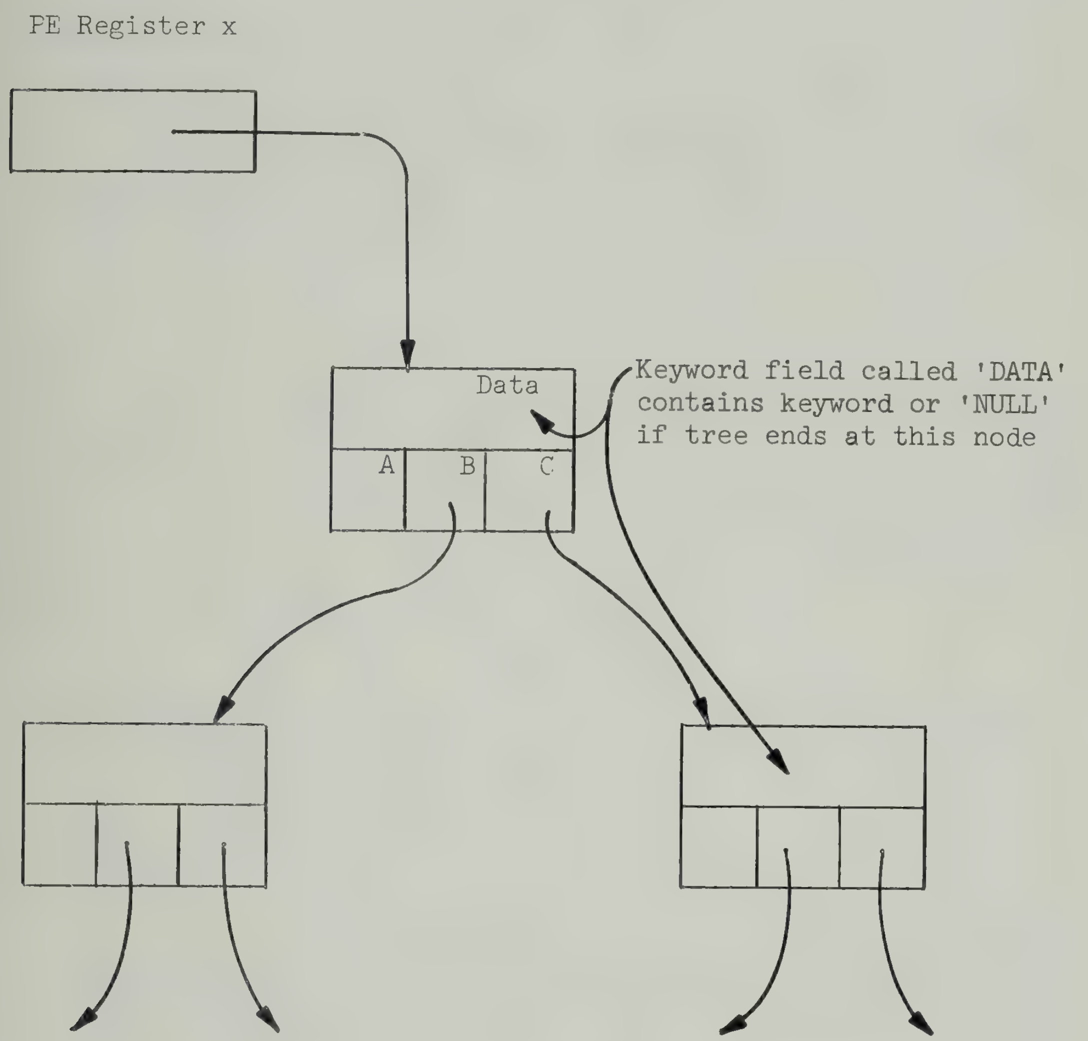


Figure 1. Arrangement of Data in One PEM for a Binary Tree

BINARY SEARCH

```
CU INTEGER PROCEDURE SEARCH (KEY, X); VALUE X;
          CU ALPHA REGISTER KEY;
          PE POINTER REGISTER X;
    BEGIN
          PE ALPHA FIELD DATA (0, 0, 63);
          PE ALPHA REGISTER WORD;
          PE POINTE FIELD B(1, 32, 47), C(1, 48, 63);
          PE INTEGER FIELD A(1, 0, 31);
          LABEL THERE, HERE;
          WORD ← KEY;
HERE:     FOR ALL X . DATA ≠ "NULL"  DO
    BEGIN
          FOR ONE X . DATA = WORD DO
               BEGIN
                 SEARCH ← X . A;
                 GO TO THERE
               END;
          FOR ALL X . DATA < WORD DO  X ← X . B;
          FOR ALL X . DATA > WORD DO  X → X . C;
    END;
    GO TO HERE;
THERE:
END PROCEDURE SEARCH;
```

5.6 System K

5.6.1 Assembler

During this quarter, the basic ILLIAC IV assembler was transferred from the 7094 to the B5500 by rewriting the assembler algorithm in Burroughs Extended ALGOL. This assembler has been exhaustively checked out and is available for use in conjunction with the ILLIAC IV simulator for basic checkout of ILLIAC IV code. (In this respect, see Document No. 159)[3].

5.6.2 Simulator

The simulator program has also been successfully transferred from the 7094 to the B5500. All orders of ILLIAC IV which are currently well defined have been implemented in the simulator and checked out. In association with the basic assembler, this program suite is now available for use by applications personnel.

5.6.3 Debugging System

In recognition of the novelty of some aspects of ILLIAC IV programming, it was decided to investigate the provision of more sophisticated debugging facilities than are generally provided on commercially available machines. These debugging facilities are to be ultimately formalized as a language extension to Tranquil. This work is currently in an early stage.

As a tooth-cutting project, an investigation is being made of the feasibility of attaching the debugging language extensions to B5500 ALGOL. A temporary grammer for a metastatement in ALGOL has been developed. Such a statement should allow programmers to write tests of their code into the original code. The result of the test statement should indicate that the code passed the test, or give some diagnostic information. Some thought has been given to implementation by macrogenerating acceptable code into an ALGOL program, or by modifying an ALGOL compiler to accept the metastatements.

5.6.4 Operating System

Full-time work on this part of the ILLIAC IV software started during this quarter. An overall approach to the problem was formulated and various design criteria defined. Operating system's personnel participated in

extensive discussions about the design of the I/O interfaces of ILLIAC IV, and about the B6500 MCP.

Two major factors have affected the design of the operating system: 1) the need to preserve maximum flexibility in the control of ILLIAC IV; and 2) the importance of being able to thoroughly test the operating system in a well defined way.

Work has been done in a programming parts of a "model" operating system on the B5500 in such a way as to minimize the transferral work to B6500. A sufficient number of routines have been checked out to justify the feasibility of the basic approach.

5.6.5 B5500 Software Maintenance

Routines have been implemented to provide a generalized I/O package for the teletypes. Work is under way for provision of accurate machine time cost logging and the implementation of a file security system. Much effort has been devoted to both formal and on-the-job training of the B5500 user population.

APPLICATIONS

5.7 Partial Differential Equations

5.7.1 Introduction

This quarter has seen the initiation of a comprehensive effort to coordinate work in this area of application toward the development of a partial differential equation and matrix code library for user support. In several areas, work has begun on component routines. In addition, several continuing projects have been brought to a conclusion. Carlson's S_n method has been programmed in Tranquil. The slip flow and boundary layer problem has been coded in ALGOL for numerical study and also in Tranquil. Continued study of weapons effects' problems has resulted in an analysis of radiation density calculations, and a code in ILLIAC IV assembly language has been written which will be described in a future report.

Work has begun on the mesh generator problem for the two dimensional heat equation for convex polygonal regions, with solution by means of alternating direction techniques. An algorithm has been developed and coded in ALGOL for simplified boundary conditions, and debugging on the B5500 has started.

5.7.2 User Support Codes

It was found, in attempting to analyze the problem by writing partial differential codes for ILLIAC IV, that a rather general structure might be used on a model for a large number of codes. (It would also serve for problems in areas other than partial differential equations.) This structure has five functionally distinct parts. In simple codes, some of these may be vestigial, but they can be identified. They are: 1) Data specification; 2) storage allocation; 3) input/output; 4) stencil operations; and 5) mathematical kernels.

The data specification includes mesh generation for PDE codes. In PDE problems, this segment may calculate coordinates of grid points, make lists of neighboring points, do interpolation for initial or boundary values, and set indices or flags to mark boundaries. Information supplied to this segment will include geometry data, mesh sizes, location of interfaces, and more.

Storage allocation assumes a crucial and unique role for ILLIAC IV. Efficient use of the machine depends directly on proper storage allocation. A number of canned mappings have been found to apply to a widening class of problems, and, as more of these somewhat universal allocation schemes are found, they will be added to the library. For some problems, it may be necessary to do a line by line or block by block allocation. Statements will be provided to do this.

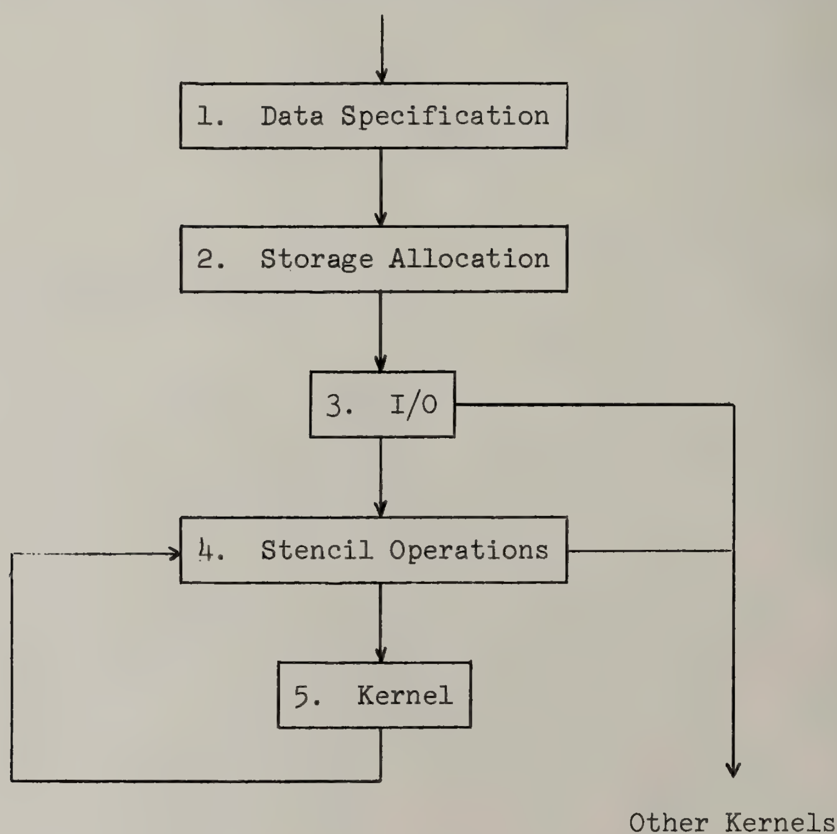
I/O, in addition to providing reading and writing of symbolic disk files and PE blocks, will also provide for graphical display of data through the B6500. In the latter area, it is expected to allow for graphing functions of two variables and simulated three-dimensional plots, with the ability to rotate and cross-section the image. It is also expected to provide for contour mapping and for the display of the map as it would appear on an arbitrary surface--i.e., a weather map on a hemisphere. It is also hoped

to have the facility for simulated three-dimensional contour mappings and for rotating and cross-sectioning the image. The graphical display package would also permit vector field graphs on arbitrary surfaces.

Stencil operations have been found useful in programming problems for irregular meshes and for expanding sparse matrices. They allow data to be addressed indirectly and they make resulting algorithms more regular and easier to write. On simple parts of the data structure, they may not be necessary.

The mathematical kernel is difficult to define exactly. In present thinking, it has come to be associated with a code without I/O which operates on stencils--the part of the code which is involved with setting up and solving the difference equation in a PDE program, inverting a matrix, or performing a sequence of transformation in an eigenvalue problem. Kernels may be written specifically or automatically generated from codes written for size independent problems.

Schematically, the following flow diagram pertains to this:



In an actual code, these segments interact in several ways. The compiler uses information from some parts in translating others--storage allocation is a declaration. At execution, parameters must be transmitted from one segment to another. Also, in real algorithms, many kernels will be linked together.

5.7.3 Slip Flow and Boundary Layer Studies

In any hydrodynamic problem involving the motion of a body in a fluid, the interest is in determining the velocity vector, the pressure, the temperature, etc., at any point in the flow field. The aerodynamic characteristics (lift, drag, etc.) of the body can then be obtained.

It is well established that the flow field can be divided into two regions: a very thin layer in the neighborhood of the body (boundary layer) where friction (viscous action) is important, and the remaining region outside this layer where viscous effects can be neglected. The governing equations for both regions--a system of nonlinear partial differential equations--are derived from the same principles which are the conservation of mass, momentum, and energy. The equations for the outer region, however, do not contain terms to account for viscous action and are called Euler's equations. For the boundary layer region, the resulting equations are the Navier-Stokes equations which are more complex.

Because of the great mathematical difficulties connected with solving the full Navier-Stokes equations, certain approximations are usually introduced into these equations to simplify them. Such approximations lead to the, so-called, boundary layer equations. The task of solving the boundary layer equations is the main and only theme of the boundary layer theory. It should be mentioned that the form of the boundary layer equations and the difficulty encountered in solving them depends on the geometry of the body and the manner in which it is moving.

The classical boundary conditions for the velocity vector W and the temperature are $W = 0$, $T = T_w$ respectively, at the surface of the body, where T_w is the wall temperature of the body. It has been established that in certain situations, these classical boundary conditions are not appropriate (the criterion is the value of a parameter called the rarefaction parameter).

In such circumstances, which are often encountered in outer space where the density is very low or in hypersonic speeds, the above boundary conditions are replaced by the velocity slip and temperature jump boundary conditions at the wall.

The simplest problem in which velocity slip rather than zero velocity should be used as a boundary condition is the slow motion of a flat plate in a rarefied flow field. The governing equations for this problem are:

$$U \frac{\partial U}{\partial x} + \frac{\partial U}{\partial y} = \nu \frac{\partial^2 U}{\partial y^2} \qquad \nu = \text{constant},$$

$$\frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} = 0$$

where all quantities are nondimensionalized by normalizing them. This system of equations can be reduced to a single second order partial differential equation by introducing the stream function Ψ and using the von Mises transformation. The resulting equation is:

$$\frac{\partial U}{\partial x} = \frac{1}{Re_{\gamma\infty}} \frac{\partial}{\partial \Psi} \left[U \frac{\partial U}{\partial \Psi} \right] \quad (1), \; U = U(\Psi, x)$$

where $U = \frac{\partial \Psi}{\partial y}$; $V = -\frac{\partial \Psi}{\partial x}$; $Re_{\gamma\infty}$ is the Reynold's number based on the free stream mean free path.

The transformed boundary conditions are:

$$U(\Psi, 0) = 1$$

$$\left.\frac{\partial U}{\partial \Psi}\right|(0, x) = 1$$

$$U(\infty, x) = 1$$

In the present study, equation (1) has already been solved by using a difference scheme suggested very recently by Milton Lees for a similar equation but with different boundary conditions than the above ones. The results of the solution were in good agreement with another solution developed in a laborious way by W. L. Chow who did not transform the system of equations to equation (1) and did not employ the mesh or grid technique to arrive at his numerical solution.

The success of the difference scheme used for equation (1) encouraged its application to a more sophisticated boundary layer problem in which the speed does not have to be slow, the density does not have to be low, and the heat transfer effects are not neglected. The governing equations for this suggested problem, in the X - Ψ space are:

$$\frac{\partial U}{\partial x} = \frac{1}{Re_{\gamma\infty}} \frac{\partial}{\partial \Psi}\left[T^{n-1} U \frac{\partial U}{\partial \Psi}\right],$$

$$\frac{\partial T}{\partial x} = \frac{Re_{\gamma\infty}}{Pr} \frac{\partial}{\partial \Psi}\left[U \frac{\partial T}{\partial \Psi}\right] + (\lambda-1) M_\infty^2 \; U \left(\frac{\partial U}{\partial \Psi}\right)^2$$

where $U = U(\Psi, x)$ and $T = T(\Psi, x)$.

An attempt is now being made to solve the above system of equations, by using the velocity slip and temperature jump boundary conditions one time and by using the no slip, no jump boundary conditions the next time.

5.7.4 Matrix Operations

An algorithm for multiplying a sparse matrix times a sparse matrix was developed and coded in ILLIAC IV assembly language. To form the product A x B where A and B are sparse, the algorithm simultaneously forms dot products of the form $a_r b_i$ $1 \leq i \leq 256$ where a_r is a row vector of A, and b_i is a column vector of B [or a section of a row (column) vector of length 256 when A (B) is m x n, m > 256 (n > 256)].

The algorithm consists of two sections. The first section determines which multiplications have to be performed. Since these multiplications, in general, vary from column to column and thus from PE to PE, a queue consisting

of the nonzero elements of a_r that are to be used together with a tag denoting which element of b_i is to be used is formed in each PE.

The second section performs the multiplications using the information and the operands stored in the queue. Thus, a PE only has to be disabled when its total number of multiplications is less than the total number of multiplications of another PE.

To illustrate, consider $a_r \times B$ where:

$$a_r = [a_1, 0, 0, a_4, a_5, 0]$$

$$B = \begin{bmatrix} b_{11} & b_{12} & 0 & 0 \\ 0 & b_{22} & 0 & b_{24} \\ b_{31} & 0 & 0 & 0 \\ 0 & 0 & b_{43} & b_{44} \\ b_{51} & b_{52} & b_{53} & 0 \\ 0 & b_{62} & 0 & b_{64} \end{bmatrix}$$

B is stored as:

PE	1	2	3	4
	b_{11}	b_{12}	b_{43}	b_{24}
	b_{31}	b_{22}	b_{53}	b_{44}
	b_{51}	b_{52}		b_{64}
		b_{62}		

The queue looks like:

PE	1	2	3	4	
	1	1	1	2	
	a_1	a_1	a_4	a_4	tags
	3	3	2		
	a_5	a_5	a_5		

Note that the tags do not refer to the row index of the b element but to the position of the element in the packed array.

5.7.5 Mathematical Service Routines

This quarter has seen the initiation of an effort to develop codes for standard algebraic and trigonometric functions and routines for ILLIAC IV. Several codes are being written, and the analysis for others has been undertaken.

A square root code (64 bit) has been completed. The technique used is essentially that of finding a close approximation and then applying Newton's method, a fixed number of times--a standard procedure.

A polynomial root finder using the techniques of multisectioning to find simple roots and then applying Bainstow's method for multiple roots is nearing completion.

Codes for log, sine, and cosine are under development.

5.7.6 Carlson's S_n Method

The programming of steady-state neutron transport in Tranquil was done during this quarter. The stead-state neutron transport was of the type existing in an homogeneous isotropic medium with no upscattering or independent source. Another characteristic was that it was of one dimensional spherical geometry assuming 32 velocity groups, 14 angular directions (Carlson's

discrete S_{14} formulation), and 128 spatial mesh points. At full efficiency, 8 processing elements calculate the inner solution for 32 groups simultaneously. Details are recorded in a separate ILLIAC IV document.

5.8 Signal Processing

5.8.1 Application of ILLIAC IV to Phased Array Radar for Area Defense

The use of the ILLIAC IV computer in handling data for large phased array radars for ICBM Area Defense has been investigated. A particular phased array radar system was modeled, assuming a certain number of objects, and programmed for single quadrant operation on ILLIAC IV. This single quadrant will be more than sufficient to handle the real time data processing requirements of radar control, scanning, designation, and tracking of potential targets.

The phased array radar model assumed has separate transmitter and receiver arrays. The radar system is capable of scanning 10^{11} resolution elements/second. These may have as many as 10^8 apparent targets from which 3×10^2 to 3×10^3 should be tracked as possible targets for further discrimination. The transmitter has four quadrants which can operate, gather, or transmit four separate pulses simultaneously. Each quadrant has 12,544 radiating elements and requires 113 steering commands for each transmission. The receiver consists of clusters of elements where each cluster can operate independently. There are 20 clusters for scanning, 2 for designation, and 5 for tracking and multiple use; each cluster can receive 9 beams simultaneously.

The three major functions which require most of the computer time (steering commands, designation, track) have been programmed for ILLIAC IV operations and are presently undergoing simulation debugging for the B5500 computer. This major operation requires approximately 50% full computer capability of the single quadrant. A detailed report documenting the procedure for handling the problem is presently in the final stages of preparation.

5.9 Matrices

5.9.1 Eigenvalue Problems

In the last quarter, emphasis was given to eigenvalue problems of symmetric matrices. During this quarter, the eigenvalue problems for

non-symmetric matrices were dealt with (QR-algorithm). It was found that the QR-algorithm with a single origin shift will speed up the convergence greatly. It was also found that using a double origin shift is more advantageous in the case of complex-pair eigenvalues. The full report on Jacobi, Householder, and the QR-algorithm has been completed. The Tranquil language codes for the three methods are included in the report.

5.10 Linear Programming

5.10.1 Introduction

The study of linear programming has been directed to the writing of a totally, memory contained LP code in ILLIAC IV assembly language by using the general form revised simplex algorithm and to the investigation of a new algorithm for large scale linear programming problems.

5.10.2 LP Code

The totally contained LP code is quite suitable for the solution of relatively small scale linear programming problems, such as a size of 600 x 1000 or smaller. The main feature of this case is its simplicity, since no input-output operations are involved. A complete procedure description, including mathematical procedures and computational procedures, will soon appear in two ILLIAC IV Documents. This code will be simulated by the ILLIAC IV simulator using 64 bit precision. No other numerical provision is being included, such as reinversion of basis to restore the precision at some point of iteration.

The new algorithm for large scale linear programming problems attempts to make use of the great sparsity of the activity matrix and the formulation of the revised simplex method. This new algorithm is the product form revised simplex method which has been proven to be computationally effective in handling larger scale linear programming problems in which the general form revised simplex method is no longer effectively applicable. This new algorithm has received thorough investigaticn. Proper mathematical procedures have been formulated in terms of the product form revised simplex method and made applicable to the ILLIAC IV computer. A brief comparison between the general form revised simplex method and the product form revised simplex

method was made in order to visualize the advantages of the product form revised simplex method over the general form revised simplex method.

5.11 Computer Graphics

5.11.1 Introduction

Over the last quarter, ILLIAC IV's investigation of large scale weather calculations has reached the conclusion that general circulation modeling is a highly parallel process (as are most partial differential equations problems) to which ILLIAC IV can be efficiently applied. As in all applications, the real difficulty in using ILLIAC IV to simulate the large scale motion of the atmosphere lies in storing data across memory in such a way that the PE's can be used efficiently. In general, it seems that most global grid systems likely to be used in meteorology can be broken into large rectangle-like blocks, each of which can be stored in the machine in a straight-forward way. This, of course, does not eliminate the need for clever programming, but is a significant step towards parallelism.

5.11.2 NCAR Model

Two heartening results related to the NCAR model have appeared in the last quarter. The first involved a model comparable numerically to that coded and timed for ILLIAC IV, but not core contained. Also, assuming a disk block size of 256 words/PE, the ratio of block transmission time between disk and ILLIAC IV memory to computation time on 1 block of data is approximately 1 to 10. This allows I/O to be effectively masked by computation. The second involved a very simple calculation related to general circulation modeling. The ratio of execution time on NCAR's CDC 6600 (problem coded in FORTRAN IV) to estimated ILLIAC IV execution time (hand timed machine code) was 800 to 1--a substantial speedup.

5.11.3 Weather Mapping Algorithm

A great simplification occurred in the weather mapping algorithm when it was learned that the vectors do not need to be ordered to follow the contour lines. The reason for this is that weather maps are difficult to interpret if they contain too many contour lines. With a smaller number

of contour lines, a display is fast enough to draw the vectors in a random manner without flicker. It is now apparent that a complete weather map can be generated in about one millisecond with all the work done in ILLIAC IV in a highly efficient manner.

5.11.4 Graphical Display System

Work this quarter has centered on debugging the graphical display system described in last quarter's QPR. The system is presently operating on an IBM 7094 with output to a Calcomp platter (via tape) and on a CDS 1604 with output direct to a scope. Parts of the system have run on the B5500; but as that machine does not allow independent subroutines, there is doubt as to whether the present version of the system will be used on it. Present work is centered on detailed debugging and improvements of this system and on the definition and use of surfaces in this system.

5.12 Weapons Effects Calculations

During this period, the performance of the ILLIAC IV on weapons effects calculations was studied. The specific problems investigated were Eulerian hydrodynamics in two and three dimensions, and the solution of the radiation transport problem by the method of long characteristics.

Because of the assumed symmetry in the r direction in 2-D hydro, it is required that the number of cells in the Z direction equal roughly twice the number of cells in the r direction. Since 5 hydro quantities per cell must be stored, the total number of hydro cells must be less than 100,000. Subject to these constraints, the largest mesh that can be core contained with skewed storage is 256 x 125. However, there is a different method of storage allocation that will accommodate the entire 100,000 cells. The single material problem with a closed form equation of state was coded in assembly language and timed. It requires roughly 4000 clocks to advance the hydro quantities one time cycle in 256 cells. With an efficient I/O buffering scheme, it is possible to do very large mesh calculations with no apparent delays for the I/O.

No interesting 3-D problem can be core contained. Although the compute time per cell increases by about 30% over 2-D, the number of cells

that can be contained in a core load decreases by about a factor of 3. The I/O required per cell in 3-D is roughly double that required by 2-D. Because of these factors, the 3-D problem is I/O bound. If disc transfer rates were roughly doubled, the I/O bound would disappear.

The radiation transport problem was coded in Tranquil and then "hand" compiled. The hand compiled code (which may be quite different from the code produced by the compiler) requires about 5000 clocks to determine the radiation transport in a single direction and single frequency group across 256 eulerian cells. There appears to be no significant I/O problem.

Very interesting problems occur in multimaterial hydro (in the equation of state routine) and in the table look-up procedure required to do radiation transport. These problems are explained and possible solutions proposed in two ILLIAC IV documents now in preparation.

5.13 Anthropology Applications

5.13.1 Population Genetic Program

At this time, the experimentation with full chromosomal simulation in 'SCATRE' has been completed. This work demonstrated the feasibility of developing such a program for the ILLIAC IV. Although the model itself was shown to be operable, it is also apparent, both from the results of this experiment and from discussion with geneticists, that the scale and detail accuracy of the model would have to be improved for later exacting scientific use. A program is now under development in ALGOL for the B5500 which will test several other techniques for possible inclusion in an ILLIAC IV program. The original model was limited by small population size and small amounts of chromosomal material per individual, so that its development of trait forms was limited to a few small elementary linear, scalar, threshold characters with two levels of integration. The B5500 experiments will include several expansions. Instead of just simple phase shift and substitution mutations (which will also be done by a new algorithm), there will be included algorithms to simulate crossovers, loops, and other such higher level randomizing and sorting factors. A seven level non-scalar integrative and combinatorial plan for phenotype determination and several possible mating schemes will be tried along with some techniques of pseudo-simulation

(recording the state of the stabile parts of the chromosome by a register indicating "changed/same"), thus saving space for more program density and population size. The code for several of the above algorithms has already been generated, but they have not yet been tested in a combined model. The exact form of the final ILLIAC IV model will depend on the results of these experiments.

5.13.2 Other Applications

Work on other applications has, to date, been confined to exploratory discussions of possible uses of computers in Anthropology with special respect being paid to the specific capabilities of the ILLIAC IV. Possible future programs include: Archeology--the establishment of n-dimensional matrices of time, space, and form related data of pot sherds and other artifacts, and the manipulation of these matrices to discover patterns of continuity both in strata and in evolutionary progression; Physical Anthropology--the application of transformation algorithms to constellations of points representing fossil material to determine continuities and aberations; Social Anthropology--the possibility has emerged that a fast efficient computer such as the ILLIAC IV will allow the expansion of some of the traditional theories of sociograms combined with the ideas of the social network theory and certain mathematical tools and concepts from graph theory such as the m-clique into a significant tool for ethnographic evaluation; Theoretical Anthropology--recent inquiries indicate a possible relationship between the ideas of Levi-Straus, the theory of binary cognitive models, and explorations in the character of such binary networks as are found in the retina of the eye; such that computer simulation might be a possible tool of analysis. Further applications are also under consideration.

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6. NUMERICAL METHODS, COMPUTER ARITHMETIC AND ARTIFICIAL LANGUAGES

(Supported in part by the National Science Foundation under Grant No. NSF-GP-4636.)

6.1 Computerized Mathematics

In this quarter, we considered a theorem proving procedures involving the predicate calculus. In the formulation of the predicate calculus considered, theorems are represented by sets of clauses, each clause a disjunction of predicates or negations of predicates, and each predicate a truth value mapping of variables or functions of variables of an underlying space. All variables are universally quantified, so the quantifiers are not written. The procedure considered, called resolution, is a generalization of the deduction: If A => B and B => C, then A => C. For a pair of clauses D and E, a substitution for some of the variables in D and E is made which will allow an inference of the type above. The inferred clause is called a resolvent of D and E, and D and E are the resolvends. A pair of clauses may have many resolvents. The resolution of a set S of clauses, R(S), is the set of clauses which are in S or are resolvents of pairs of clauses in S. The nth resolution $R^n(S)$ is $R(R^{n-1}(S))$. Robinson ("A Machine Oriented Logic Based on the Resolution Principle," JACM, Vol. 12, 1965) showed that a set S of clauses represents a true theorem if, and only if, $R^n(S)$ contains the empty clause for some finite n. If S represents a false proposition, resolution never terminates. A proof for S is a sequence of clauses $A_1, A_2, \ldots A_n$ such that each A_i is either in S or a resolvent of of two clauses A_j, A_k, $j, k < i$ and A_n is the empty clause.

If resolution is performed on a computer, then in general, only a much smaller set of clauses than $R^n(S)$ needs to be generated to find the empty clause. Let T be a subset of S. Let $T_1 = T$ and T_{i+1} be the set of

clauses which are either in T_i or a resolvent of a clause in T_i with a clause in $T_i \cup S$. T is called a set of support.

In this quarter, we gave a sufficient condition for a set T to be a valid set of support, i.e., T_n contains the empty clause for finite n if, and only if, S represents a true theorem.

Theorem: T is a valid set of support for S if T contains at least one clause appearing in some proof for S.

As a simple corollary we have the following:

Corollary: T is a valid set of support if S-T is a consistent set of support.

The above results, along with some lemmas used to prove the theorem, were incorporated into a master's thesis* which was completed in December.

The theorem provides a large class of sets of support for a set S of clauses. In the coming quarter, we plan to write a program to help to learn how to choose sets of support which will minimize the time required to find a proof for S.

(D. B. Gillies, L. J. Henschen)

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* Henschen, Lawrence J., "Some New Results on Resolution in Automated Theorem Proving." University of Illinois, master's thesis, December 1967.

6.2 Autonomous Arithmetic Unit Structures

The development of an on-line system for the preparation and analysis of flow charts was initiated. This system is based very heavily on the work of F. K. Richardson and T. Y. Lo of this department.

(M. J. Pisterzi)

6.3 Algebraic Manipulation

The study of the use of finite field models in polynomial manipulation was continued. A set of theorems establishing the validity of the models has been developed and is being prepared for publication.

One subclass of models appears to be particularly well suited for polynomial manipulation. These models can be used to detect and localize errors produced during polynomial addition and multiplication while at the same time have the capability of probabilistically predicting divisibility properties. For example, if the model of polynomial A does not divide that of polynomial B, it may be concluded that A does not divide B. However, if the model of A divides B there is a probability (usually close to one but depending on the model) that A divides B. This probability can be brought closer to one by repeating the division with models of A and B which are more exact but still in the same class and hence easily derivable.

All of the polynomial models studied depend on a prime subfield and consequently the properties of the prime and operations in this prime field require attention. Addition and multiplication modulo the prime are the most frequent operations but when the models are used for division, inversion also becomes important. Three algorithms for finding the inverse were studied, two of which have not yet been described in the

literature. In these two, the maximum and average numer of modular multiplications required does not seem to have an analytic solution so tables have been prepared by computer for sets of primes close to 2^n for n up to 13.

(S. J. Nuspl)

6.4 Symbol Manipulation Languages EOL

The EOL implementation on the IBM 7094 is now completed. Students in the CS 109 honors course were the first users of the new language, and each of them completed as a term project a program to compile arithmetic expressions into assembly language programs.

We will now implement the present version of EOL on the IBM 360, and also work on improvement, in the language.

(F. Fischer, M.Irwin-Zarecki,
J. Nievergelt, and J. Sidlo)

7. COMPUTATIONAL PHYSICS

The new approximation scheme for evaluating conditional Wiener integrals referred to in the last quarter of the progress report has been applied to the quartic oscillator. Further tests of this method are in progress.

L. D. Fosdick, Project Director
R. C. Jacobson

8. SWITCHING THEORY AND LOGICAL DESIGN

A new approach for the logical design of optimum networks by integer linear programming was assumed by C. R. Baugh, T. Ibaraki, T. K. Liu and S. Muroga, after Gomory's algorithm was found insufficient for our design problem. The new approach is based upon Balas' algorithm with Fleishman's improvement and we incorporated our gimmicks to speed up the computer execution time of the approach. It was rewritten in FORTRAN IV and we found a fantastic improvement over Gomory's algorithm. Only a small number of switching functions which require four NOR gates could be solved by Gomory's algorithm, each function requiring about one hour of ILLIAC II. All functions of four NOR gates are solved by the new approach, each requiring a few seconds of the IBM 360 Model 75. All functions of five NOR gates are also solved, each requiring a half minute. We are working on the functions of six NOR gates. If the increase of computation time of six NOR gates over the case of five NOR gates is not great, our design method based on integer linear programming would have practical value.

The placement problem of logic elements into packages is being formulated, using integer linear programming. Non-linear terms are incorporated. This mathematical technique is being extended to the problem of minimization of interconnection among packages.

S. Muroga

9. ILLIAC II SERVICE, USE, AND PROGRAM DEVELOPMENT

(This work is supported in part by Contract No. AT(11-1)-1469 of the Atomic Energy Commission and in part by the University of Illinois.)

9.1 ILLIAC II Program Development

(See Section 3.)

9.2 Library Programming

9.2.1 Mathematical Subroutine Library

In this quarter, the following subroutines were put into FØRTLIB:

F1-UOI-HOUSEZ-15F-F

IDENTIFICATION--Householder's method for symmetric matrices.

F2-UOI-BKTRNZ-16F-F

IDENTIFICATION--Eigenvectors by back transformation.

F2-UOI-SOL1Z-14F-F

IDENTIFICATION--Solution of a set of simultaneous linear equations.

F4-UOI-SOL2Z-14F-F

IDENTIFICATION--Solution of a set of simultaneous linear equations.

F2-UOI-TSTMT2-10F-F

IDENTIFICATION--Test matrices.

F3-UOI-DET1Z-11F-F

IDENTIFICATION--Cholesky decomposition.

F3-UOI-DET2Z-12F-F

IDENTIFICATION--Cholesky decomposition.

9.3 ILLIAC Operation

The following is a list of how the ILLIAC II was used for this quarter.

	October	November	December
AEC and Other Test	195:43	165:15	142:25
Scheduled Enginerring	36:44	40:38	42:17
Unscheduled Engineering	52:35	38:26	47:23
Time Share	160:54	154:32	142:26
Update and Development	36:30	84:16	121:31
Batch Processing (in house only)	29:09	21:14	27:06
Other In House Users	90:30	106:22	117:52
Demonstrations	20:35	8:10	6:00
Down Time	62:14	46:12	24:51
Unaccounted For Time	20:05	53:55	12:09
Total Time in Month	744:00	724:00	744:00

9.4 CS Library - Information Retrieval

360 programs for constructing a KWIC index similar to the KWIC index previously made on the IBM 1401 were prepared. They are now being debugged and it is anticipated that they will be operational in the next quarter. The necessary data from all books and most volumes of printing and tables have already been put on punched cards.

L. D. Fosdick, Project Director
S. T. Baird

10. IBM 7094/1401 SERVICE, USE, AND PROGRAM DEVELOPMENT

(Supported in part by the National Science Foundation under Grant No. NSF-GP-7634).

10.1 New Routines - IBM System/360

QO-UØI-DATEZ-4F-A

Date Routine for FORTRAN IV and Assembler programs. The routine uses the TIME macro to obtain the date and convert it to a standard form.

Written by Carol Deck
October 1, 1967

QO-UØI-ITIMEZ-5F-A

Timing Routine for FORTRAN IV and Assembler programs. This routine returns the elapsed time from midnight or the elasped time from a specified earlier call to the routine. The routine uses the TIME macro, which returns the time from midnight in 1/100ths of a second.

Written by Carol Deck
October 1, 1967

F4-UØI-XINVZ-6F-A

Inversion of a Real Symmetric Matrix by the Method of Successive Bordering. The determinant is automatically computed and returned as a byproduct.

Converted from 7094
routine XINV by
Carol Deck
October 1, 1967

10.2 Log Summaries

Table I - IBM 1401-II

Summary of Use

October, 1967

Scheduled Engineering	7:35
Unscheduled Engineering	17:01
Maintenance	6:43
7094 Preparation	445:54
List/Reproduce	20:25
Code Check	3:45
Tape Dump	3:57
1604 Preparation	6:57
ILLIAC II	4:25
List Conversion Program	12:30
Idle	76:56
Total	606:08

Table II - IBM 1401-II

Summary of Machine Errors

October, 1967

1401 Main Frame	1
1402 Card Reader Punch	3
1403 Printer	3
Total	7

B L A N K

Table I - IBM 1401-IV

Summary of Use

October, 1967

Scheduled Engineering	6:40
Unscheduled Engineering	11:20
Maintenance	6:26
7094 Preparation	537:34
List/Reproduce	32:10
Code Check	4:10
Tape Dump	2:08
1604 Preparation	:35
ILLIAC II	3:30
List Conversion Program	15:30
Idle	40:36
Total	660:39

Table II - IBM 1401-IV

Summary of Machine Errors

October, 1967

1403 Card Reader Punch	3
Total	3

Table I - IBM 7094

Summary of Use

October, 1967

Scheduled Engineering			29:28
Unscheduled Engineering			4:24
Maintenance			7:22
Idle			47:36
Miscellaneous (Operator training, tape rewind, system tape mounting, rerun of failing problems)			70:00
Total Use			
Training and Education		41:48	
University Administrative Overhead Use		14:03	
System Modification and Improvement		20:15	
System Updating		4:01	
Customer Use			
In System	388:27		
Relinquish	4:24		
Special Short Shots	1:03		
Customer Use Total		393:54	
	Total Use		474:01
	Total Time		632:51

Table II - IBM 7094

Summary of Errors

October, 1967

Tape Unit		3
	Total	3

7094 Table III October, 1967

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
AAE	217	125	342	4	5	9	1 44.8	2 58.6	4 43.4
ACCY	783	3	786	1	2	3	14 39.7	40.4	15 20.2
ADMRE	0	12	12	0	1	1	0.0	38.9	38.9
AGE	20	190	210	1	7	8	2.8	1 57.7	2 0.6
AGEC	0	135	135	0	12	12	0.0	6 10.0	6 10.0
AGRON	456	115	571	1	10	11	1 32.7	2 31.0	4 3.8
ANS	0	132	132	0	4	4	0.0	3 59.8	3 59.8
ANTH	17	0	17	1	0	1	15.0	0.0	15.0
ARCH	45	0	45	1	0	1	10.7	0.0	10.7
ASTR	0	139	139	0	7	7	0.0	1 59.6	1 59.6
BECBS	0	27	27	0	1	1	0.0	43.9	43.9
BEDRE	0	9	9	0	2	2	0.0	3.5	3.5
BINRE	0	35	35	0	1	1	0.0	30.5	30.5
BIOPH	0	36	36	0	1	1	0.0	1 2.2	1 2.2
BOT	0	2	2	0	1	1	0.0	0.6	0.6
BOTAN	0	10	10	0	1	1	0.0	1.7	1.7
CCDME	0	2	2	0	1	1	0.0	0.4	0.4
CE	457	1253	1710	8	41	49	3 56.8	37 23.2	41 20.0
CHE	29	1651	1680	4	43	47	5.2	53 19.1	53 24.4
COMM	0	7	7	0	1	1	0.0	22.6	22.6
CP	0	8	8	0	2	2	0.0	6.8	6.8
CRC	0	77	77	0	3	3	0.0	3 35.3	3 35.3
CSL	0	13	13	0	1	1	0.0	23.8	23.8
CURLA	0	91	91	0	1	1	0.0	48.5	48.5
CZR	0	11	11	0	1	1	0.0	28.8	28.8
DCS	359	208	567	3	7	10	1 54.7	5 37.4	7 32.2
DOW	0	41	41	0	1	1	0.0	46.9	46.9
DS	0	132	132	0	3	3	0.0	11 56.6	11 56.6
ECON	0	54	54	0	5	5	0.0	35.6	35.6
ED	0	93	93	0	10	10	0.0	2 44.8	2 44.8
EDPSY	131	1	132	1	1	2	44.2	15.2	59.4
EDTES	0	16	16	0	1	1	0.0	14.3	14.3
EE	379	577	956	7	20	27	1 54.5	8 16.8	10 11.3
ENTOM	0	3	3	0	1	1	0.0	1.0	1.0

7094 Table III October, 1967 Continued

Dept[1]	Number of Runs T and E[2]	Number of Runs Res	Number of Runs Total	Number of Specs T and E[2]	Number of Specs Res	Number of Specs Total	7094 Usage in Hours-Minutes T and E[2]	7094 Usage in Hours-Minutes Res	7094 Usage in Hours-Minutes Total
FIN	0	4	4	0	1	1	0.0	7.1	7.1
FOR	0	7	7	0	2	2	0.0	1.7	1.7
FT	0	6	6	0	1	1	0.0	0.8	0.8
GENE	27	0	27	1	0	1	8.6	0.0	8.6
GEOG	4	0	4	1	0	1	1.3	0.0	1.3
GEOL	5	10	15	1	1	2	28.8	5.2	34.1
GSBA	49	0	49	5	0	5	1 42.2	0.0	1 42.2
HEC	0	1	1	0	1	1	0.0	0.7	0.7
HED	0	57	57	0	1	1	0.0	1 53.6	1 53.6
HORT	0	43	43	0	2	2	0.0	29.8	29.8
ICR	0	110	110	0	2	2	0.0	3 31.2	3 31.2
IE	5	0	5	1	0	1	1.0	0.0	1.0
IED	0	33	33	0	1	1	0.0	1 10.4	1 10.4
ILR	0	29	29	0	1	1	0.0	33.2	33.2
INADM	0	38	38	0	1	1	0.0	9.9	9.9
IREC	0	59	59	0	4	4	0.0	2 23.9	2 23.9
LIBS	0	6	6	0	1	1	0.0	1 41.5	1 41.5
MATH	0	7	7	0	1	1	0.0	13.4	13.4
MATRL	0	711	711	0	23	23	0.0	15 5.3	15 5.3
MCBIO	0	10	10	0	1	1	0.0	3.4	3.4
ME	1129	702	1831	13	27	40	6 54.1	13 30.9	20 25.0
MKTG	0	6	6	0	1	1	0.0	2.5	2.5
MMPE	0	167	167	0	3	3	0.0	4 25.9	4 25.9
MUSIC	0	4	4	0	1	1	0.0	7.5	7.5
NHS	0	10	10	0	3	3	0.0	41.9	41.9
NUCE	30	696	726	2	16	18	16.2	11 42.3	11 58.6
OAC	0	40	40	0	1	1	0.0	1 40.5	1 40.5
OIR	0	148	148	0	1	1	0.0	7 44.8	7 44.8
PEM	0	43	43	0	1	1	0.0	9.7	9.7
PEW	0	32	32	0	1	1	0.0	18.1	18.1
PHYB	0	123	123	0	5	5	0.0	1 45.6	1 45.6
PHYCS	1	780	781	1	16	17	0.1	20 27.4	20 27.6
PHYSL	0	109	109	0	3	3	0.0	1 6.4	1 6.4
PHYX	0	1907	1097	0	9	9	0.0	107 49.0	107 49.0
POLS	48	52	100	1	3	4	2 44.1	1 55.5	4 39.7
PSYCH	68	620	688	3	20	23	59.1	12 37.0	13 36.1

7094 Table III October, 1967 Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
REC	0	23	23	0	1	1	0.0	57.9	57.9
SCONS	0	43	43	0	1	1	0.0	51.0	51.0
SCS	0	2	2	0	1	1	0.0	1.9	1.9
SGS	0	100	100	0	2	2	0.0	1 30.8	1 30.8
SOC	149	80	229	1	1	2	1 13.7	53.2	2 7.0
SOCW	0	27	27	0	2	2	0.0	36.7	36.7
SRL	0	56	56	0	1	1	0.0	1 58.0	1 58.0
SSU	0	11	11	0	1	1	0.0	7 40.4	7 40.4
SWS	0	296	296	0	13	13	0.0	7 48.8	7 48.8
TAM	10	450	460	1	14	15	8.8	5 54.2	6 3.0
VPH	0	8	8	0	1	1	0.0	6.8	6.8
VPP	0	37	37	0	1	1	0.0	7.8	7.8
VTED	0	43	43	0	1	1	0.0	9.5	9.5
WPGU	0	10	10	0	1	1	0.0	9.5	9.5
XSSS[3]	0	159	159	0	1	1	0.0	1 2.9	1 2.9
ZOOL	8	14	22	1	2	3	7.6	8.3	15.9
Subtotal	4426	13137	17563	64	397	461	41 47.9	393 54.1	435 42.1
DCSSY[4]	0	1464	1464	0	12	12	0.0	20 14.7	20 14.7
XDCS[5]	0	118	188	0	1	1	0.0	4 1.3	4 1.3
SSUAD[6]	0	468	468	0	3	3	0.0	14 3.0	14 3.0
Total	4426	15187	19613	64	413	477	41 47.9	432 13.1	474 1.1

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
4 System Improvement and Modifications
5 System Updating
6 University Administrative Overhead Use

Table I - IBM 360/50

Summary of Use

October, 1967

Scheduled Engineering			35:37
Unscheduled Engineering			13:30
Maintenance			3:29
Total Use			
Training and Education		179:48	
University Administrative Overhead Use		75:41	
System Modification and Improvement and Updating		132:09	
Customer Use			
In System	65:41		
Special Short Shots	:30		
Customer Use Total		66:11	
Total Use			453:49
Total Time			506:25

Table II - IBM 360/50

Summary of Errors

October, 1967

Card Read Punch	4
Disk Units	6
Total	10

IBM 360/50 Table III October, 1967

Dept[1]	Number of Runs T and E[2]	Number of Runs Res	Number of Runs Total	Number of Specs T and E[2]	Number of Specs Res	Number of Specs Total	360 Usage in Hours-Minutes T and E[2]	360 Usage in Hours-Minutes Res	360 Usage in Hours-Minutes Total
AAE	204	56	260	6	2	8	8 55.4	3 1.5	11 56.9
ACCY	35	0	35	1	0	1	1 25.4	0.0	1 25.4
AGE	5	14	19	2	1	3	7.1	16.8	24.0
AGEC	0	84	84	0	2	2	0.0	1 33.5	1 33.5
AGRON	0	37	37	0	3	3	0.0	49.1	49.1
CE	635	69	704	5	5	10	14 13.8	5 45.5	19 59.4
CHE	73	51	124	4	3	7	2 1.9	1 22.3	3 24.2
CP	4	0	4	1	0	1	3.4	0.0	3.4
CRC	0	8	8	0	2	2	0.0	9.6	9.6
DCS	8326	233	8559	6	4	10	145 3.6	14 54.2	159 57.9
CE	0	5	5	0	1	1	0.0	1.6	1.6
DCS	0	168	168	0	3	3	0.0	9 13.7	9 13.7
ECON	0	7	7	0	1	1	0.0	38.1	38.1
ED	1	4	5	1	1	2	0.2	6.4	6.7
EE	64	13	77	4	2	6	1 15.7	50.0	2 5.8
ENGAD	0	82	82	0	1	1	0.0	6 30.7	6 30.7
ENGCS	0	45	45	0	1	1	0.0	5 39.1	5 39.1
ENGH	103	0	103	1	0	1	1 46.7	0.0	1 46.7
GSBA	44	0	44	1	0	1	1 48.6	0.0	1 48.6
HEC	0	5	5	0	1	1	0.0	7.8	7.8
MATRL	0	5	5	0	1	1	0.0	6.5	6.5
ME	55	0	55	5	0	5	59.5	0.0	59.5
NUCE	81	0	81	2	0	2	2 5.8	0.0	2 5.8
PHYCS	0	32	32	0	3	3	0.0	1 25.7	1 25.7
PHYX	0	169	169	0	4	4	0.0	12 28.0	12 28.0
SGS	0	2	2	0	1	1	0.0	2.5	2.5
WPGU	0	8	8	0	1	1	0.0	10.5	10.5
XSSS[3]	0	17	17	0	1	1	0.0	30.4	30.4
ZOOL	0	17	17	0	2	2	0.0	26.8	26.8
Subtotal	9630	1131	10761	39	46	85	179 47.8	66 11.7	245 59.6
DCSSY[4]	0	1281	1281	0	12	12	0.0	132 8.8	132 8.8
SSUAD[5]	0	98	98	0	3	3	0.0	75 40.7	75 40.7
Total	9630	2510	12140	39	61	100	179 47.8	274 1.2	453 49.1

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots

Table I - IBM 1401-II

Summary of Use

November, 1967

Scheduled Engineering	5:35
Unscheduled Engineering	8:55
Maintenance	7:16
7094 Preparation	511:01
List/Reproduce	43:13
Code Check	5:15
Tape Dump	:37
1604 Preparation	:32
Air Conditioning	:05
LCP	5:15
ILLIAC II Preparation	1:10
Idle	38:06
Total	627:00

Table II - IBM 1401-II

Summary of Machine Errors

November, 1967

1401 Main Frame	1
1402 Card Reader Punch	6
Total	7

Table I - IBM 1401-IV

Summary of Use

November, 1967

Scheduled Engineering		4:55
Unscheduled Engineering		34:05
Maintenance		7:47
7094 Preparation		512:14
List/Reproduce		29:47
Code Check		1:06
Tape Duplication		:20
Tape Dump		:40
1604 Preparation		:05
LCP		4:25
ILLIAC II Preparation		1:13
Idle		23:24
	Total	620:01

Table II - IBM 1401-IV

Summary of Machine Errors

November, 1967

1401 Main Frame		2
1402 Card Reader Punch		3
1406 Core Storage		1
729V Tape Drives		2
	Total	8

Table I - IBM 7094

Summary of Use

November, 1967

Scheduled Engineering			33:23
Unscheduled Engineering			2:05
Machine Maintenance			10:53
Idle			17:13
Miscellaneous (Operator training, tape rewind, system tape mounting, rerun of failing problems)			88:31
Total Use			
Training and Education		45:08	
University Administrative Overhead Use		13:33	
System Modification and Improvement		31:31	
System Updating		10:26	
Customer Use			
In System	379:14		
Relinquish	2:20		
Special Short Shots	:38		
Customer Use Total		382:12	
	Total Use		482:50
	Total Time		634:55

Table II - IBM 7094

Summary of Errors

November, 1967

Tape Drives		2
	Total	2

7094 Table III November, 1967

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
AAE	183	99	282	5	6	11	3 3.8	1 47.5	4 51.4
ACCY	412	0	412	1	0	1	6 39.0	0.0	6 39.6
ADMRE	0	14	14	0	1	1	0.0	47.4	47.4
ADV	0	1	1	0	1	1	0.0	0.0	0.0
AGE	24	148	172	1	6	7	8.9	2 12.4	2 21.4
AGEC	12	106	118	2	12	14	3.4	4 45.8	4 49.3
AGRON	60	135	195	1	13	14	18.1	2 10.6	2 28.7
ANS	0	144	144	0	3	3	0.0	3 46.5	3 46.5
ANTH	28	0	28	1	0	1	1 45.0	0.0	1 45.0
ARCH	64	0	64	2	0	2	22.6	0.0	22.6
ASTR	12	154	166	1	7	8	4.9	2 11.8	2 16.7
BECBS	0	71	71	0	2	2	0.0	2 25.6	2 25.6
BED	0	4	4	0	1	1	0.0	2.4	2.4
BEDRE	0	12	12	0	1	1	0.0	23.2	23.2
BINRE	0	34	34	0	1	1	0.0	13.9	13.9
BIOPH	0	1	1	0	1	1	0.0	0.0	0.0
BOT	0	8	8	0	2	2	0.0	6.1	6.1
CCSCS	0	3	3	0	1	1	0.0	1.2	1.2
CE	638	1348	1986	8	42	50	4 34.6	36 54.4	41 29.0
CHE	393	1848	2241	5	53	58	2 25.3	63 13.2	65 38.5
COMM	0	11	11	0	1	1	0.0	13.7	13.7
CP	0	18	18	0	2	2	0.0	14.2	14.2
CPUBS	0	2	2	0	1	1	0.0	8.6	8.6
CRC	0	40	40	0	3	3	0.0	1 3.4	1 3.4
CSL	0	1	1	0	1	1	0.0	2.4	2.4
CURLA	0	19	19	0	2	2	0.0	12.5	12.5
CZR	0	37	37	0	1	1	0.0	1 53.8	1 53.8
DCS	607	53	660	3	4	7	3 15.6	1 52.4	5 8.1
DOW	0	27	27	0	1	1	0.0	41.6	41.6
DS	0	149	149	0	3	3	0.0	18 45.8	18 45.8
ECON	0	11	11	0	2	2	0.0	3.5	3.5
ED	0	92	92	0	7	7	0.0	1 53.3	1 53.3
EDPSY	90	5	95	1	1	2	38.8	7.3	46.1
EE	511	537	1048	10	27	37	2 31.1	8 39.0	11 10.2

7094 Table III November, 1967 Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
ENTOM	0	3	3	0	1	1	0.0	8.5	8.5
FIN	0	9	9	0	1	1	0.0	20.9	20.9
FOR	0	8	8	0	1	1	0.0	1.6	1.6
GENE	48	0	48	2	0	2	9.4	0.0	9.4
GEOG	23	0	23	1	0	1	4.4	0.0	4.4
GEOL	6	16	22	2	2	4	6.7	6.4	13.1
GSBA	7	0	7	2	0	2	4.5	0.0	4.5
HED	0	62	62	0	1	1	0.0	3 13.6	3 13.6
HORT	0	5	5	0	2	2	0.0	1.9	1.9
ICR	0	96	96	0	1	1	0.0	1 58.9	1 58.9
IE	90	0	90	1	0	1	26.7	0.0	26.7
IED	0	86	86	0	1	1	0.0	58.2	58.2
INADM	14	23	37	1	1	2	9.4	6.7	16.2
IREC	0	57	57	0	4	4	0.0	1 19.1	1 19.1
LIBS	0	2	2	0	1	1	0.0	26.9	26.9
MATH	0	9	9	0	1	1	0.0	4.3	4.3
MATRL	0	633	633	0	20	20	0.0	10 52.0	10 52.0
MCBIO	0	2	2	0	1	1	0.0	0.0	0.0
ME	979	775	1754	15	29	44	4 17.1	16 48.2	21 5.4
MKTG	7	9	16	1	1	2	21.6	4.2	25.9
MMPE	12	149	161	1	4	5	2 58.4	3 52.1	6 50.6
MUSIC	0	40	40	0	1	1	0.0	1 2.6	1 2.6
NHS	0	18	18	0	3	3	0.0	40.0	40.0
NUCE	37	443	480	3	14	17	18.8	11 56.6	12 15.4
OAC	0	6	6	0	1	1	0.0	6.9	6.9
OIR	0	206	206	0	1	1	0.0	7 28.9	7 28.9
PEM	0	3	3	0	1	1	0.0	0.9	0.9
PEW	0	15	15	0	1	1	0.0	5.9	5.9
PHYB	0	57	57	0	3	3	0.0	1 4.7	1 4.7
PHYCS	5	848	853	1	19	20	0.9	20 24.8	20 25.7
PHYSL	0	38	38	0	3	3	0.0	40.0	40.0
PHYX	0	1819	1819	0	9	9	0.0	101 6.2	101 6.2
POLS	119	44	163	1	3	4	7 13.8	2 50.3	10 4.2
PSYCH	131	590	721	3	29	32	2 5.6	16 17.2	18 22.9
REC	0	4	4	0	1	1	0.0	0.8	0.8
SCONS	0	42	42	0	1	1	0.0	37.1	37.1

7094 Table III November, 1967 Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
SCS	0	4	4	0	1	1	0.0	2.3	2.3
SGS	0	52	52	0	2	2	0.0	42.3	42.3
SOC	115	113	228	1	3	4	57.9	1 49.1	2 47.0
SOCW	0	11	11	0	2	2	0.0	23.3	23.3
SSU	0	7	7	0	1	1	0.0	3 18.4	3 18.4
SWS	0	300	300	0	16	16	0.0	8 12.9	8 12.9
TAM	0	300	300	0	10	10	0.0	4 44.3	4 44.3
VPH	0	4	4	0	1	1	0.0	1.3	1.3
VPP	0	36	36	0	1	1	0.0	10.4	10.4
VTED	0	14	14	0	2	2	0.0	4.3	4.3
WPGU	0	4	4	0	1	1	0.0	6.9	6.9
XSSS[3]	0	124	124	0	1	1	0.0	38.2	38.2
ZOOL	0	41	41	0	3	3	0.0	12.3	12.3
Subtotal	4627	12259	16886	76	415	491	45 8.3	382 10.8	427 19.1
DCSSY[4]	0	1352	1352	0	17	17	0.0	31 31.0	31 31.0
XDCS[5]	0	120	120	0	1	1	0.0	10 26.3	10 26.3
SSUAD[6]	0	309	309	0	3	3	0.0	13 33.3	13 33.3
Total	4627	14040	18667	76	436	512	45 8.3	437 41.4	482 49.7

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
4 System Improvement and Modifications
5 System Updating
6 University Administrative Overhead Use

Table I - IBM 360/50

Summary of Use

November, 1967

Scheduled Engineering			8:49
Unscheduled Engineering			21:25
Maintenance			:40
Air Conditioning			4:55
Total Use			
Training and Education		286:08	
University Administrative Overhead Use		23:12	
System Modification and Improvement and Updating		145:45	
Customer Use			
In System	131:06		
Special Short Shots	:30		
Customer Use Total		131:36	
Total Use			586:41
Total Time			622:30

Table II - IBM 360/50

Summary of Errors

November, 1967

Punch Unit	3
Disk Unit	3
1052 Console Typewriter	1
2050 CPU	1
2150 Display Machine	1
Total	9

IBM 360/50 Table III November, 1967

Dept[1]	Number of Runs			Number of Specs			360 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
AAE	251	92	343	4	4	8	6 8.8	4 26.2	10 35.0
ACCY	15	0	15	1	0	1	29.6	0.0	29.6
AGE	15	22	37	2	1	3	17.0	1 8.3	1 25.4
AGEC	0	12	12	0	2	2	0.0	1 19.7	1 19.7
AGRON	218	36	254	1	2	3	5 51.7	1 41.4	7 33.2
CE	839	179	1018	6	9	15	25 58.9	11 38.2	37 37.1
CHE	571	95	666	3	9	12	13 26.6	4 50.2	18 16.8
CP	59	15	74	1	2	3	49.7	31.9	1 21.7
CRC	0	17	17	0	2	2	0.0	30.7	30.7
DCS	10015	493	10508	6	7	13	203 36.2	69 37.4	273 13.7
DOW	0	1	1	0	1	1	0.0	0.5	0.5
ECON	0	19	19	0	1	1	0.0	13 59.3	13 59.3
EDADM	0	5	5	0	1	1	0.0	4.0	4.0
EE	517	17	534	11	6	17	18 6.2	16.1	18 22.4
ENGAD	0	53	53	0	2	2	0.0	2 14.8	2 14.8
ENGCS	0	11	11	0	1	1	0.0	1 3.5	1 3.5
ENGH	83	0	83	1	0	1	1 5.2	0.0	1 5.2
GEOL	70	0	70	2	0	2	3 46.5	0.0	3 46.5
GSBA	38	0	38	1	0	1	2 34.1	0.0	2 34.1
HEC	0	11	11	0	1	1	0.0	30.8	30.8
HORT	0	12	12	0	1	1	0.0	19.3	19.3
IE	54	0	54	2	0	2	1 21.1	0.0	1 21.1
MATRL	0	46	46	0	1	1	0.0	2 20.2	2 20.2
ME	48	0	48	8	0	8	52.2	0.0	52.2
MKTG	0	26	26	0	1	1	0.0	1 39.8	1 39.8
MMPE	0	10	10	0	1	1	0.0	9.6	9.6
NUCE	26	14	40	2	1	3	58.3	27.2	1 25.6
PHYB	0	3	3	0	1	1	0.0	1.2	1.2
PHYCS	1	3	4	1	2	3	0.9	3.5	4.5
PHYX	0	144	144	0	4	4	0.0	9 35.4	9 35.4

IBM 360/50 Table III November, 1967 Continued

Dept[1]	Number of Runs			Number of Specs			360 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
PSYCH	0	10	10	0	2	2	0.0	8.0	8.0
SGS	0	5	5	0	1	1	0.0	10.1	10.1
TAM	29	10	39	3	1	4	42.9	16.3	59.3
WPGU	0	23	23	0	2	2	0.0	38.7	38.7
XSSS[3]	0	54	54	0	1	1	0.0	30.2	30.2
ZOOL	0	70	70	0	4	4	0.0	1 21.7	1 21.7
Subtotal	12850	1511	14361	56	77	133	286 7.6	131 37.0	417 44.6
DCSSY[4]	0	1397	1397	0	10	10	0.0	145 44.9	145 44.9
SSUAD[5]	0	85	85	0	3	3	0.0	23 11.9	23 11.9
Total	12850	2993	15843	56	90	146	286 7.6	300 33.8	586 41.4

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
4 System Improvement and Modifications and Updating
5 University Administrative Overhead Use

Table I - IBM 1401-II

Summary of Use

December, 1967

Scheduled Engineering	11:05
Unscheduled Engineering	:11
Maintenance	4:00
7094 Preparation	475:43
List/Reproduce	20:43
Code Check	2:00
Tape Duplication	2:00
Tape Dump	7:30
LCP	19:14
ILLIAC II	:20
Idle	35:37
Total	578:23

Table II - IBM 1401-II

Summary of Machine Errors

December, 1967

1403 Printer	1
Total	1

Table I - IBM 1401-IV

Summary of Use

December, 1967

Scheduled Engineering		3:55
Unscheduled Engineering		44:42
Maintenance		5:10
7094 Preparation		468:37
List/Reproduce		32:05
Code Check		:30
Tape Dump		3:40
LCP		18:58
ILLIAC II		:30
Idle		30:00
	Total	608:07

Table II - IBM 1401-IV

Summary of Machine Errors

December, 1967

1401 Main Frame		4
1402 Card Reader Punch		9
729V Tape Drives		2
	Total	15

Table I - IBM 7094

Summary of Use

December, 1967

Scheduled Engineering			29:34
Unscheduled Engineering			17:53
Maintenance			6:51
Idle			34:27
Air Conditioning			7:00
Power Failure			3:45
Miscellaneous (Operator training, tape rewind, system tape mounting, rerun of failing problems)			82:03
Total Use			
Training and Education		51:19	
University Administrative Overhead Use		9:26	
System Modification and Improvement		25:19	
System Updating		4:09	
Customer Use			
In System	305:07		
Relinquish	4:34		
Special Short Shots	1:03		
Customer Use Total		310:44	
Total Use			400:57
Total Time			582:30

Table II - IBM 7094

Summary of Errors

December, 1967

Main Frame	1
Printer	3
Reader	2
Punch	1
Tape Drive	1
Total	8

7094 Table III December, 1967

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
AAE	106	125	231	3	7	10	30.7	1 24.3	1 55.1
ACCY	75	3	78	1	1	2	1 15.5	1.7	1 17.3
ADMRE	0	6	6	0	1	1	0.0	24.6	24.6
AGE	19	133	152	1	4	5	26.7	1 51.3	2 18.1
AGEC	338	124	462	2	13	15	1 14.4	5 53.3	7 7.7
AGRON	249	127	376	1	10	11	1 37.0	6 22.1	7 59.1
ANS	0	112	112	0	6	6	0.0	2 7.5	2 7.5
ANTH	14	0	14	1	0	1	1 46.3	0.0	1 46.3
ARCH	93	0	93	2	0	2	38.1	0.0	38.1
ASTR	43	56	99	1	4	5	13.0	56.6	1 9.7
BECBS	0	70	70	0	2	2	0.0	1 13.1	1 13.1
BED	0	5	5	0	1	1	0.0	2.6	2.6
BEDRE	0	2	2	0	1	1	0.0	17.4	17.4
BINRE	0	27	27	0	1	1	0.0	23.3	23.3
BIOPH	0	86	86	0	1	1	0.0	2 41.6	2 41.6
CCSCS	0	5	5	0	1	1	0.0	4.0	4.0
CE	1002	982	1984	9	44	53	9 26.6	27 43.1	37 9.7
CHE	96	1313	1409	4	49	53	33.4	44 51.4	45 24.9
COMM	0	13	13	0	1	1	0.0	8.0	8.0
CP	0	44	44	0	2	2	0.0	32.8	32.8
CPUBS	0	3	3	0	1	1	0.0	24.4	24.4
CRC	0	24	24	0	4	4	0.0	1 25.1	1 25.1
CURLA	0	33	33	0	2	2	0.0	9.4	9.4
CZR	0	4	4	0	1	1	0.0	11.6	11.6
DCS	917	103	1020	4	4	8	5 48.8	2 22.1	8 11.0
DOW	0	11	11	0	1	1	0.0	17.9	17.9
DS	0	68	68	0	1	1	0.0	4 37.6	4 37.6
ECON	0	40	40	0	4	4	0.0	16.9	16.9
ED	0	173	173	0	9	9	0.0	2 56.6	2 56.6
EDPSY	58	5	63	2	2	4	54.8	5.6	1 0.5
EE	550	415	965	12	25	37	3 2.2	6 44.6	9 46.9
ENTOM	0	3	3	0	1	1	0.0	11.0	11.0
FIN	0	12	12	0	2	2	0.0	33.0	33.0
FOR	0	20	20	0	2	2	0.0	6.2	6.2

7094 Table III December, 1967 Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
FT	0	8	8	0	1	1	0.0	16.4	16.4
GENE	132	0	132	3	0	3	55.4	0.0	55.4
GEOG	24	8	32	1	1	2	8.4	7.9	16.4
GEOL	25	77	102	1	3	4	6.4	42.1	48.5
GSBA	9	0	9	2	0	2	5.2	0.0	5.2
HEC	0	4	4	0	1	1	0.0	16.0	16.0
HED	0	30	30	0	1	1	0.0	2 9.8	2 9.8
HONOR	0	4	4	0	1	1	0.0	1.1	1.1
HORT	0	1	1	0	1	1	0.0	0.2	0.2
ICR	0	121	121	0	1	1	0.0	3 41.8	3 41.8
IE	91	0	91	1	0	1	28.3	0.0	28.3
IED	0	135	135	0	1	1	0.0	2 52.1	2 52.1
INADM	65	20	85	1	1	2	24.6	8.8	33.4
IREC	0	117	117	0	3	3	0.0	1 37.9	1 37.9
LIBS	0	5	5	0	1	1	0.0	1 8.6	1 8.6
MATH	0	8	8	0	1	1	0.0	2.2	2.2
MATRL	0	605	605	0	21	21	0.0	11 34.4	11 34.4
MCBIO	0	18	18	0	1	1	0.0	3.8	3.8
ME	1397	649	2046	13	27	40	6 52.4	16 5.7	22 58.2
MKTG	0	2	2	0	1	1	0.0	4.1	4.1
MMPE	10	93	103	1	3	4	2 55.4	4 32.2	7 27.7
MUSIC	0	48	48	0	1	1	0.0	1 51.6	1 51.6
NHS	0	50	50	0	3	3	0.0	3 41.0	3 41.0
NUCE	14	393	407	3	13	16	13.2	9 16.1	9 29.4
OIR	0	226	226	0	1	1	0.0	4 38.0	4 38.0
PEM	0	66	66	0	1	1	0.0	4.7	4.7
PHYB	0	15	15	0	4	4	0.0	11.2	11.2
PHYCS	18	777	795	2	19	21	8.9	21 7.9	21 16.8
PHYSL	0	25	25	0	3	3	0.0	11.3	11.3
PHYX	0	1526	1526	0	10	10	0.0	74 58.4	74 58.4
PLPA	0	16	16	0	1	1	0.0	8.0	8.0
POLS	181	41	222	3	3	6	6 52.3	1 53.4	8 45.8
PSYCH	312	598	910	3	26	29	4 5.7	14 39.1	18 44.8
REC	0	13	13	0	1	1	0.0	13.0	13.0
SCONS	0	29	29	0	1	1	0.0	22.9	22.9
SGS	0	83	83	0	2	2	0.0	48.8	48.8

7094 Table III December, 1967 Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
SOC	73	30	103	1	5	6	27.7	1 38.1	2 5.9
SOCW	0	19	19	0	2	2	0.0	1 5.5	1 5.5
SPED	0	2	2	0	1	1	0.0	7.4	7.4
SRL	0	53	53	0	1	1	0.0	25.0	25.0
SWS	0	295	295	0	15	15	0.0	5 4.8	5 4.8
TAM	0	246	246	0	9	9	0.0	3 27.8	3 27.8
VPH	0	33	33	0	1	1	0.0	13.1	13.1
VPP	0	36	36	0	1	1	0.0	18.6	18.6
VTED	0	22	22	0	1	1	0.0	7.4	7.4
WPGU	0	5	5	0	1	1	0.0	8.8	8.8
XSSS[3]	0	180	180	0	1	1	0.0	1 2.8	1 2.8
ZOOL	1	33	34	1	4	5	5.6	9.2	14.8
Subtotal	5912	10912	16824	79	409	488	51 18.6	310 44.5	362 3.1
DCSSY[4]	0	670	670	0	17	17	0.0	25 19.3	25 19.3
XDCS[5]	0	52	52	0	1	1	0.0	4 8.8	4 8.8
SSUAD[6]	0	198	198	0	3	3	0.0	9 26.2	9 26.2
Total	5912	11832	17744	79	430	509	51 18.6	349 38.8	400 57.4

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
4 System Improvement and Modifications
5 System Updating
6 University Administrative Overhead Use

Quarterly Summary of Departmental 7094 Running Time

October, November, December, 1967

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
AAE	506	349	855	12	18	30	5 19.4	6 10.6	11 30.0
ACCY	1270	6	1276	3	3	6	22 34.9	42.2	23 17.2
ADMRE	0	32	32	0	3	3	0.0	1 51.1	1 51.1
ADV	0	1	1	0	1	1	0.0	0.0	0.0
AGEC	350	365	715	4	37	41	1 17.8	16 49.2	18 7.1
AGE	63	471	534	3	17	20	38.5	6 1.6	6 40.1
AGRON	765	377	1142	3	33	36	3 27.9	11 3.8	14 31.7
ANS	0	388	388	0	13	13	0.0	9 53.9	9 53.9
ANTH	59	0	59	3	0	3	3 46.4	0.0	3 46.4
ARCH	202	0	202	5	0	5	1 11.5	0.0	1 11.5
ASTR	55	349	404	2	18	20	17.9	5 8.1	5 26.0
BECBS	0	168	168	0	5	5	0.0	4 22.7	4 22.7
BEDRE	0	23	23	0	4	4	0.0	44.2	44.2
BED	0	9	9	0	2	2	0.0	5.0	5.0
BINRE	0	96	96	0	3	3	0.0	1 7.7	1 7.7
BIOPH	0	123	123	0	3	3	0.0	3 43.9	3 43.9
BOTAN	0	10	10	0	1	1	0.0	1.7	1.7
BOT	0	10	10	0	3	3	0.0	6.8	6.8
CCDME	0	2	2	0	1	1	0.0	0.4	0.4
CCSCS	0	8	8	0	2	2	0.0	5.2	5.2
CE	2097	3583	5680	25	127	152	17 58.0	102 0.8	119 58.9
CHE	518	4812	5330	13	145	158	3 4.0	161 23.9	164 27.9
COMM	0	31	31	0	3	3	0.0	44.4	44.4
CPUBS	0	5	5	0	2	2	0.0	33.1	33.1
CP	0	70	70	0	6	6	0.0	54.0	54.0
CRC	0	141	141	0	10	10	0.0	6 3.9	6 3.9
CSL	0	14	14	0	2	2	0.0	26.3	26.3
CURLA	0	143	143	0	5	5	0.0	1 10.5	1 10.5
CZR	0	52	52	0	3	3	0.0	2 34.3	2 34.3
DCS	1883	364	2247	10	15	25	10 59.2	9 52.1	20 51.4
DOW	0	79	79	0	3	3	0.0	1 46.6	1 46.6
DS	0	349	349	0	7	7	0.0	35 20.2	35 20.2
ECON	0	105	105	0	11	11	0.0	56.1	56.1
EDPSY	279	11	290	4	4	8	2 17.9	28.1	2 46.1
EDTES	0	16	16	0	1	1	0.0	14.3	14.3
ED	0	358	358	0	26	26	0.0	7 34.9	7 34.9

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
AAE	106	125	231	3	7	10	30.7	1 24.3	1 55.1
ACCY	75	3	78	1	1	2	1 15.5	1.7	1 17.3
ADMRE	0	6	6	0	1	1	0.0	24.6	24.6
AGE	19	133	152	1	4	5	26.7	1 51.3	2 18.1
AGEC	338	124	462	2	13	15	1 14.4	5 53.3	7 7.7
AGRON	249	127	376	1	10	11	1 37.0	6 22.1	7 59.1
ANS	0	112	112	0	6	6	0.0	2 7.5	2 7.5
ANTH	14	0	14	1	0	1	1 46.3	0.0	1 46.3
ARCH	93	0	93	2	0	2	38.1	0.0	38.1
ASTR	43	56	99	1	4	5	13.0	56.6	1 9.7
BECBS	0	70	70	0	2	2	0.0	1 13.1	1 13.1
BED	0	5	5	0	1	1	0.0	2.6	2.6
BEDRE	0	2	2	0	1	1	0.0	17.4	17.4
BINRE	0	27	27	0	1	1	0.0	23.3	23.3
BIOPH	0	86	86	0	1	1	0.0	2 41.6	2 41.6
CCSCS	0	5	5	0	1	1	0.0	4.0	4.0
CE	1002	982	1984	9	44	53	9 26.6	27 43.1	37 9.7
CHE	96	1313	1409	4	49	53	33.4	44 51.4	45 24.9
COMM	0	13	13	0	1	1	0.0	8.0	8.0
CP	0	44	44	0	2	2	0.0	32.8	32.8
CPUBS	0	3	3	0	1	1	0.0	24.4	24.4
CRC	0	24	24	0	4	4	0.0	1 25.1	1 25.1
CURLA	0	33	33	0	2	2	0.0	9.4	9.4
CZR	0	4	4	0	1	1	0.0	11.6	11.6
DCS	917	103	1020	4	4	8	5 48.8	2 22.1	8 11.0
DOW	0	11	11	0	1	1	0.0	17.9	17.9
DS	0	68	68	0	1	1	0.0	4 37.6	4 37.6
ECON	0	40	40	0	4	4	0.0	16.9	16.9
ED	0	173	173	0	9	9	0.0	2 56.6	2 56.6
EDPSY	58	5	63	2	2	4	54.8	5.6	1 0.5
EE	550	415	965	12	25	37	3 2.2	6 44.6	9 46.9
ENTOM	0	3	3	0	1	1	0.0	11.0	11.0
FIN	0	12	12	0	2	2	0.0	33.0	33.0
FOR	0	20	20	0	2	2	0.0	6.2	6.2

7094 Table III December, 1967 Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
FT	0	8	8	0	1	1	0.0	16.4	16.4
GENE	132	0	132	3	0	3	55.4	0.0	55.4
GEOG	24	8	32	1	1	2	8.4	7.9	16.4
GEOL	25	77	102	1	3	4	6.4	42.1	48.5
GSBA	9	0	9	2	0	2	5.2	0.0	5.2
HEC	0	4	4	0	1	1	0.0	16.0	16.0
HED	0	30	30	0	1	1	0.0	2 9.8	2 9.8
HONOR	0	4	4	0	1	1	0.0	1.1	1.1
HORT	0	1	1	0	1	1	0.0	0.2	0.2
ICR	0	121	121	0	1	1	0.0	3 41.8	3 41.8
IE	91	0	91	1	0	1	28.3	0.0	28.3
IED	0	135	135	0	1	1	0.0	2 52.1	2 52.1
INADM	65	20	85	1	1	2	24.6	8.8	33.4
IREC	0	117	117	0	3	3	0.0	1 37.9	1 37.9
LIBS	0	5	5	0	1	1	0.0	1 8.6	1 8.6
MATH	0	8	8	0	1	1	0.0	2.2	2.2
MATRL	0	605	605	0	21	21	0.0	11 34.4	11 34.4
MCBIO	0	18	18	0	1	1	0.0	3.8	3.8
ME	1397	649	2046	13	27	40	6 52.4	16 5.7	22 58.2
MKTG	0	2	2	0	1	1	0.0	4.1	4.1
MMPE	10	93	103	1	3	4	2 55.4	4 32.2	7 27.7
MUSIC	0	48	48	0	1	1	0.0	1 51.6	1 51.6
NHS	0	50	50	0	3	3	0.0	3 41.0	3 41.0
NUCE	14	393	407	3	13	16	13.2	9 16.1	9 29.4
OIR	0	226	226	0	1	1	0.0	4 38.0	4 38.0
PEM	0	66	66	0	1	1	0.0	4.7	4.7
PHYB	0	15	15	0	4	4	0.0	11.2	11.2
PHYCS	18	777	795	2	19	21	8.9	21 7.9	21 16.8
PHYSL	0	25	25	0	3	3	0.0	11.3	11.3
PHYX	0	1526	1526	0	10	10	0.0	74 58.4	74 58.4
PLPA	0	16	16	0	1	1	0.0	8.0	8.0
POLS	181	41	222	3	3	6	6 52.3	1 53.4	8 45.8
PSYCH	312	598	910	3	26	29	4 5.7	14 39.1	18 44.8
REC	0	13	13	0	1	1	0.0	13.0	13.0
SCONS	0	29	29	0	1	1	0.0	22.9	22.9
SGS	0	83	83	0	2	2	0.0	48.8	48.8

Table I - IBM 360/50

Summary of Use

December, 1967

Scheduled Engineering			47:21
Unscheduled Engineering			3:54
Maintenance			1:49
Total Use			
Training and Education		171:40	
University Administrative Overhead Use		2:02	
System Modification and Improvement and Updating		259:29	
Customer Use			
In System	56:57		
Special Short Shots	1:02		
Customer Use Total		57:59	
Total			491:10
Total Time			544:14

Table II - IBM 360/50

Summary of Errors

December, 1967

2314 Control Unit	2
1052 Console Typewriter	1
Total	3

IBM 360/50 Table III December, 1967

Dept[1]	Number of Runs			Number of Specs			360 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
AAE	250	114	364	4	4	8	9 29.8	4 56.6	14 26.5
ACCY	19	0	19	1	0	1	54.4	0.0	54.4
AGE	4	23	27	1	2	3	4.1	32.7	36.9
AGEC	0	2	2	0	1	1	0.0	6.5	6.5
AGRON	71	61	132	1	2	3	1 30.4	1 47.5	3 18.0
BOT	0	4	4	0	1	1	0.0	2.6	2.6
CE	874	83	957	8	7	15	21 49.1	4 36.0	26 25.1
CHE	234	95	329	4	10	14	4 7.5	2 36.2	6 43.7
CP	0	6	6	0	1	1	0.0	9.9	9.9
CRC	0	11	11	0	2	2	0.0	15.9	15.9
DCS	6352	398	6750	8	8	16	112 38.1	23 3.2	135 41.3
ECON	0	1	1	0	1	1	0.0	7.9	7.9
EDADM	0	22	22	0	1	1	0.0	15.8	15.8
EE	752	59	811	12	7	19	9 24.0	1 21.3	10 45.4
ENGAD	0	55	55	0	3	3	0.0	2 32.8	2 32.8
ENGCS	0	24	24	0	1	1	0.0	1 27.5	1 27.5
ENGH	133	0	133	1	0	1	1 43.4	0.0	1 43.4
GENE	3	0	3	1	0	1	2.4	0.0	2.4
GEOL	77	0	77	2	0	2	1 49.3	0.0	1 49.3
GER	6	0	6	1	0	1	30.8	0.0	30.8
GSBA	14	0	14	2	0	2	18.4	0.0	18.4
HEC	0	7	7	0	1	1	0.0	19.9	19.9
HORT	0	24	24	0	1	1	0.0	25.2	25.2
IE	31	0	31	1	0	1	38.2	0.0	38.2
ILLDM	0	32	32	0	1	1	0.0	1 1.3	1 1.3
INADM	5	0	5	1	0	1	4.3	0.0	4.3
MATH	3	22	25	1	1	2	2.8	15.8	18.7
MATRL	0	42	42	0	4	4	0.0	1 42.9	1 42.9
ME	44	10	54	4	2	6	1 2.5	4.0	1 6.5
MKTG	0	12	12	0	1	1	0.0	17.6	17.6
MMPE	0	17	17	0	1	1	0.0	12.1	12.1
NUCE	43	66	109	2	5	7	1 54.7	1 52.5	3 47.3

IBM 360/50 Table III December, 1967 Continued

Dept[1]	Number of Runs			Number of Specs			360 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
OIR	0	5	5	0	2	2	0.0	3.4	3.4
PHYB	0	10	10	0	1	1	0.0	13.7	13.7
PHYCS	1	5	6	1	2	3	0.4	21.4	21.8
PHYX	0	84	84	0	5	5	0.0	3 37.1	3 37.1
PSYCH	21	14	35	1	2	3	38.3	21.1	59.5
REC	0	1	1	0	1	1	0.0	0.2	0.2
SGS	0	3	3	0	1	1	0.0	7.5	7.5
SWS	0	9	9	0	2	2	0.0	19.4	19.4
TAM	164	45	209	5	2	7	2 55.3	28.4	3 23.8
USGS	0	6	6	0	1	1	0.0	3.5	3.5
WPGU	0	12	12	0	1	1	0.0	24.1	24.1
XSSS[3]	0	69	69	0	1	1	0.0	1 2.2	1 2.2
ZOOL	0	45	45	0	2	2	0.0	51.5	51.5
Subtotal	9102	1498	10600	63	91	154	171 39.8	57 59.5	229 39.3
DCSSY[4]	0	1847	1847	0	10	10	0.0	259 29.3	259 29.3
SSUAD[5]	0	57	57	0	2	2	0.0	2 1.6	2 1.6
Total	9102	3402	12504	63	103	166	171 39.8	319 30.4	491 10.2

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
4 System Modification, Improvements, and Updating
5 University Administrative Overhead Use

Quarterly Summary of Departmental Running Time

October, November, December 1967

Dept[1]	Number of Runs			Number of Specs			360 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
AAE	706	262	968	15	10	25	24 34.6	12 24.4	36 59.0
ACCY	69	0	69	3	0	3	2 49.6	0.0	2 49.6
AGE	24	59	83	5	4	9	28.4	1 58.0	2 26.5
AGEC	0	98	98	0	5	5	0.0	2 59.8	2 59.8
AGRON	289	134	423	2	7	9	7 22.2	4 18.2	11 40.4
BOT	0	4	4	0	1	1	0.0	2.6	2.6
CE	2348	339	2687	19	24	44	62 1.9	22 2.2	84 4.2
CHE	878	241	1119	11	22	33	19 36.1	8 25.3	28 1.4
CP	63	21	84	2	3	5	53.3	41.9	1 35.2
CRC	0	36	36	0	6	6	0.0	56.3	56.3
DCS	24693	1292	25985	20	22	42	461 18.1	116 48.7	578 6.8
DOW	0	1	1	0	1	1	0.0	0.5	0.5
ECON	0	27	27	0	3	3	0.0	14 45.5	14 45.5
ED	1	4	5	1	1	2	0.2	6.4	6.7
EDADM	0	27	27	0	2	2	0.0	19.9	19.9
EE	1333	89	1422	27	15	42	28 46.0	2 27.6	31 13.7
ENGAD	0	190	190	0	6	6	0.0	11 18.4	11 18.4
ENGCS	0	80	80	0	3	3	0.0	8 10.2	8 10.2
ENGH	319	0	319	3	0	3	4 35.5	0.0	4 35.5
GENE	3	0	3	1	0	1	2.4	0.0	2.4
GEOL	147	0	147	4	0	4	5 35.9	0.0	5 35.9
GER	6	0	6	1	0	1	30.8	0.0	30.8
GSBA	96	0	96	4	0	4	4 41.2	0.0	4 41.2
HEC	0	23	23	0	3	3	0.0	58.6	58.6
HORT	0	36	36	0	2	2	0.0	44.5	44.5
IE	85	0	85	3	0	3	1 59.3	0.0	1 59.3
ILLDM	0	32	32	0	1	1	0.0	1 1.3	1 1.3
INADM	5	0	5	1	0	1	4.3	0.0	4.3
MATH	4	22	26	2	1	3	3.2	15.8	19.1
MATRL	0	93	93	0	6	6	0.0	4 9.7	4 9.7
ME	147	10	157	17	2	19	2 54.3	4.0	2 58.3
MKTG	0	38	38	0	2	2	0.0	1 57.5	1 57.5
MMPE	0	27	27	0	2	2	0.0	21.8	21.8
NUCE	150	80	230	6	6	12	4 59.0	2 19.8	7 18.8

Quarterly Summary of Departmental Running Time

October, November, December 1967 Continued

Dept[1]	Number of Runs			Number of Specs			360 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
OIR	0	5	5	0	2	2	0.0	3.4	3.4
PHYB	0	13	13	0	2	2	0.0	14.9	14.9
PHYCS	2	40	42	2	7	9	1.4	1 50.7	1 52.1
PHYX	0	397	397	0	13	13	0.0	25 40.6	25 40.6
PSYCH	21	24	45	1	4	5	38.3	29.2	1 7.6
REC	0	1	1	0	1	1	0.0	0.2	0.2
SGS	0	10	10	0	3	3	0.0	20.2	20.2
SWS	0	9	9	0	2	2	0.0	19.4	19.4
TAM	193	55	248	8	3	11	3 38.2	44.8	4 23.1
USGS	0	6	6	0	1	1	0.0	3.5	3.5
WPGU	0	43	43	0	4	4	0.0	1 13.4	1 13.4
XSSS[3]	0	140	140	0	3	3	0.0	2 3.0	2 3.0
ZOOL	0	132	132	0	8	8	0.0	2 40.1	2 40.1
Subtotal	31582	4140	35722	158	214	372	637 35.3	255 24.8	893 0.1
DCSSY[4]	0	4525	4525	0	32	32	0.0	537 23.1	537 23.1
SSUAD[5]	0	240	240	0	8	8	0.0	100 54.2	100 54.2
Total	31582	8905	40487	158	254	412	637 35.3	893 42.1	1531 17.4

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
4 System Improvement, Modifications, and Updating
5 University Administrative Overhead Use

LIST OF DEPARTMENT CODES

If your department or office does not appear on this list, please write its full name in the department field on the Problem Specification Form even though it will require more than 6 characters.

ACCY	Accountancy
ADMREC	Admissions and Records
ADV	Advertising
AAE	Aeronautical and Astronautical Eng.
AGEC	Agricultural Economics
AGE	Agricultural Engineering
AGREXT	Agricultural Extension
AGRON	Agronomy
ANS	Animal Science
ANTH	Anthropology
ARCH	Architecture
ASTR	Astronomy
BIOPH	Biophysics
BOT	Botany
BCMPL	Bureau of Community Planning
BECBSR	Bureau of Economic Business Research
BEDRES	Bureau of Educational Research
BINRES	Bureau of Institutional Research
BED	Business Education
CZR	Center for Zoonoses Research
CERE	Ceramic Engineering
CPUBS	Champaign Public Schools
CHE	Chemistry and Chemical Engineering
CRC	Children's Research Center
CP	City Planning
CE	Civil Engineering
COMM	Communications
CURLAB	Curriculum Laboratory
DS	Dairy Science
DCS	Department of Computer Science
DGS	Division of General Studies
DUE	Division of University Extension
DOW	Division of Waterways
ECON	Economics
ED	Education
EDPSY	Educational Psychology
EDADM	Educational Admin. and Supervision
EDTEST	Educational Testing
EE	Electrical Engineering
ENGADM	Engineering Administration
ENGCST	Engineering College and Station
ENGH	Engineering Honors Program
ENGLSH	English
ENTOM	Entomology
EDC	Extension Division Counseling
FIN	Finance
FT	Food Science
FOR	Forestry
GENE	General Engineering
GEOG	Geography
GEOL	Geology
GER	German
GSBA	Graduate School of Business Admin.
HED	Health Education
HLTHSV	Health Service
HEC	Home Economics
HONORS	Honors Program
HORT	Horticulture
ILLDMH	Illinois Dept. of Mental Health
INADM	Industrial Administration
IE	Industrial Engineering
IREC	Institute for Researh on Exc. Children
ICR	Institute of Communications Research
IGPA	Institute of Govt. and Public Affairs
ILR	Institute of Labor and Ind. Relations
LIBS	Library Science
LING	Linguistics
MKTG	Marketing
MATRL	Materials Research Laboratory
MATH	Mathematics
ME	Mechanical Engineering
MCBIO	Microbiology
MMPE	Mining, Metallurgy, and Petroleum Eng.
MUSIC	Music
NHS	Natural History Survey
NUCE	Nuclear Engineering
OAC	Office of Agricultural Communication
DNW	Office of the Dean of Women
OIR	Office of Instructional Resources
PEM	PE for Men and Graduate PE
PEW	PE for Women
PHYPLA	Physical Plant
PHYCS	Physics
PHYB	Physics Betatron Laboratory
PHYX	Physics Project X
PHYSL	Physiology and Biophysics
PLPA	Plant Pathology
POLS	Political Science
PROVST	Provost's Office
PSYCH	Psychology
REC	Recreation
SHCBRC	Small Homes Council
SOCW	Social Work
SOC	Sociology
SCONS	Soil Conservation Service
SPED	Special Education
PSDEC	Special Education, Decatur Pub. Schools
SPCH	Speech and Theatre
SGS	State Geological Survey
SWS	State Water Survey
SCS	Student Counseling Service
SRL	Survey Research Laboratory
TAM	Theoretical and Applied Mechanics
USGS	U.S. Geological Service
UNIHI	University High School
UCCTE	Urbana-Champaign Coun. on Teacher Ed.
VMS	Veterinary Medical Science
VMA	Veterinary Medicine Administration
VPH	Veterinary Pathology and Hygiene
VPP	Veterinary Physiology and Pharmacology
VTED	Vocational and Technical Education
WPGU	WPGU Radio Station
ZOOL	Zoology

Chicago Circle

CCCHE	Chemistry
CCDME	Materials Engineering
CCENEN	Energy Engineering
CCPHCS	Physics
CCSOC	Sociology
CCSCS	Student Counseling Service

Medical Center

ORME	Office of Research in Medical Ed.
OT	Occupational Therapy

Ill. State University

ISEDAD	Department of Education Administration

11. PROBLEM SPECIFICATIONS

During the fourth quarter of 1967, 210 problem specifications were submitted to the Department for computation. The following brief descriptions of these problems have been prepared for inclusion in this report by those submitting them. T indicates a calculation associated with a thesis.

2807-70005 Materials Research Laboratory. Tunneling in Semiconductors. The tunneling current and conductance in metal-semiconductor, p-n, and metal-insulator-metal tunnel junctions are calculated using the tunneling-Hamiltonian formalism. Evaluation of the contributions to the current due to the creation of elementary excitations in the barrier region will be made as well as evaluation of the elastic tunneling current. The calculation of the current is carried out by first solving Schrödinger's equation to obtain the transition amplitude for tunneling and subsequently numerically integrating the resulting transition probability for the allowed tunneling processes. (C. B. Duke)

2808-70006 Civil Engineering. Behavior of Reinforced Concrete Beam-Columns and Arches. The object of the proposed research is to obtain fundamental knowledge on the behavior under load of curved and straight reinforced concrete members subjected to axial load and moment. In particular, knowledge on properties such as: moment redistribution and creation of plastic hinges with rotational capacities will be sought to increase the existing knowledge of limit analysis of reinforced concrete structures. The study of the behavior of members subjected to axial loads and bending moments (beam-columns and arches) requires a numerical procedure of analysis, among other reasons, because of the inelastic behavior of the constituent materials: concrete and reinforcing steel. It is not possible to obtain a closed form solution of the governing differential equations, when the modulus of elasticity of the member varies in each section as a function of the acting loads. The latter determine whether the section is cracked or not, and whether the concrete and steel are in the elastic or inelastic range. A numerical method can be found that when programmed for execution in the computer, will simulate the short-time load testing of a reinforced concrete member from which the entire behavior under load can be obtained. It is essential in obtaining realistic results that the assumptions in which the numerical method is based be of a fundamental nature.

The stress-strain diagrams of the constituent materials, the general laws of geometry and statics and the linearity of strain distribution in a section are the only assumptions that are required for a general method of analysis. The major portion of the research is to be devoted to obtain the controlling parameters in the behavior. The influence of the variation of such parameters as: 1) the concrete strength; 2) the yield point and strain hardening of reinforcement; 3) the percentage of reinforcement in the section; 4) the ratio of existing axial load to ultimate axial load of the section; 5) the ratio of midspanrise to span of the arch and other parameters, may be readily studied by means of the numerical procedure. It is possible that in the final analysis, simple and accurate expressions to predict the behavior of these members will be found, which may be of valuable use in the advancement of limit design procedures in reinforced concrete structures. (German Gurfinkel)

2809-70007 T Materials Research Laboratory. Thermal Conductivity of Niobium. In the measurement of thermal conductivity at low temperatures, computer processing of raw data is necessary for accurate cryogenic thermometry. The computer will be used in the calibration of carbon resistance thermometers in the range 0.3° Kelvin to 10° Kelvin. Having calibrated the carbon resistance thermometers, it is further necessary to express the absolute temperature in terms of the experimental values of resistance. It is also necessary to obtain the first and second derivatives of the resistance versus temperature curve. (Jon R. Carlson)

2810-70008 Coordinated Science Laboratory. List Search Simulation. Several computer system configurations will be simulated for the purpose of estimating the rate of processing large-volume list-structured data. At least two classes of system configuration will be simulated: (1) a system composed of standard compnents (large-volume memory plus scheduler mechanisms) and (2) a system including parallel search mechanisms (e.g., content addressable search structures and multiple arithmetic processors). (Benjamin Wang)

2811-7Ø010 Physics. Lattice Cluster Counting. It is proposed to obtain values for certain parameters appearing in the droplet model of condensation by counting the possible configurations of molecular clusters in order to determine their relative probabilities of occurrence. (Robert Simpson)

2812-7Ø012 Curriculum Laboratory. Curriculum Laboratory Physical Education Program. The general purpose of the project is to develop a physical education curriculum for high school students which takes into consideration both their physiological and psychological needs. The first year of the project will be devoted to experimentation with various ideas, methodologies, and concepts so that by the end of the year a structural guideline can be devised to be used as the framework of a longer five-to-ten-year curriculum development project. To scientifically determine and evaluate the changes occurring as a result of the inclusion or omission of experimental elements into the basic program, many tests (primarily of a physical nature, although many include the effects of self-concept on personality) are being administered at the beginning of the year. A re-test will take place near the end of the year. Some tests will be repeated several times during the year in order to determine whether changes have occurred due to emphasis on a particular aspect of the curriculum. Statistical treatment of the data will be concerned primarily with correlations between physical tests. Of importance also will be correlation between certain of the physical tests and scores on different aspects of personality and self-concept. It is hoped that by the end of the first year of the project, enough information will be available so that many of the physical tests which appear to be redundant or of little value can be eliminated. Computations to be performed will include mean, correlation coefficient, variance, rank, range, median, centile, standard scores, t scores, and linear regression. If a need occurs for any other types of statistical treatment, then those will also be performed. (Diane Wakat)

2813-7Ø013 T Aeronautical and Astronautical Engineering. Calculation of the Incompressible Laminar Boundary Layer. The problem concerns the calculation of incompressible laminar boundary layer characteristics including the effects of displacement thickness on the boundary layer development. The goal of the project is to extend existing techniques to cover the case of a boundary layer with small regions of separated flow. The computer

will be used primarily to numerically integrate ordinary differential equations associated with approximate methods in boundary layer theory. In addition, certain definite integrals arising from potential flow theory must be treated numerically. (T. E. Edwards)

2814-7Ø014 Materials Research Laboratory. Langer Model Test. The problems associated with phase transitions pose great difficulties for theoretical physicists; and the aim of this work is to evaluate the behavior of the Langer Model in the region of the phase transition, using a high-temperature series expansion, so as to test its relevance to phase transitions occurring in nature. The first sixteen terms in this high-temperature series are required, and the labor involved in obtaining them can be much reduced by using the computer to perform the most common manipulation occurring, which is the multiplication of polynomials. The series will then be analyzed with the aid of Pade approximates. (M. A. Moore)

2815-7Ø015 Mechanical Engineering. Radiant Storage. The problem is to maintain and update parametric matrices used in the solution of radiant heat transfer problems. (L. D. Savage)

2816-7Ø016 Admissions and Records. Administrative Research for the Office of the University Dean of Admissions and Records. A series of research studies have been designed to validate present admission procedures and to explore new admission models at both the undergraduate and graduate levels at the University of Illinois. Several studies are related to student characteristics at the three campuses: Urbana-Champaign, Chicago Circle and the Medical Center - at all levels, lower division, upper division and the Graduate College. The data will be obtained from the student data system of the University of Illinois. The computer facilities will be used to obtain descriptive indices such as means, standard deviations, first order and multiple correlations, frequency counts, and item analyses. The data will be used by University officials concerned with policy governing student admission and retention. (J. Paraskevopoulos)

2817-7∅017 T Psychology. Natural Language Mediation and Knowledge of Results in Paired-Associate Learning. The experiment was designed to investigate the effects of two variables, knowledge of results and natural language mediation on both the acquisition and extinction process. Two levels of knowledge of results, 50% and 100%, were used. Two lists, both containing pairs of consonant-vowel-consonant trigrams which had been previously scaled for elicitation of natural language mediators, were crossed with the two levels of knowledge of results to produce four different groups. One of the lists contained items which had elicited a high mean number of natural language mediators; the other list was composed of pairs which elicited relatively few natural language mediators. The pairs were presented by slide projection onto a blank wall. Each pair remained visible for four seconds for the 100% knowledge of results groups. The 50% groups were shown a blank slide, for 1/2 the trials. The stimulus presentation was similarly done and was constant for all groups. During the stimulus presentation, the subject was required to speak his response aloud and, if he had used a mediator to remember that response, to give that, also. All subjects were University of Illinois undergraduates enrolled in Psychology 100. They learned to a criterion of 6 out of 10 correct responses or 18 trials, whichever came first. Extinction extended for 18 trials. Analyses of variance using # of trials to criterion, # of correct responses and # mediators per trial for acquisition and # of correct responses and # mediators per trial for extinction will be performed. The individual items will also be classified in terms of rote or mediated learning and detailed analyses of both acquisition and extinction for these two types of response will be made. (Laraine Masters)

2818-7∅018 T Physical Education for Men and Graduate PE. Effects of Training and Wheat Germ Oil on Selected Fitness Tests. The study is designed to determine the effects of physical training with and without wheat germ oil on the cardiac time components and total peripheral resistance of adult men. Forty adult men (twenty-six to forty-five years of age) will be used as subjects. The main test data will be obtained from simultaneous recordings of the carotid pulse wave, phonocardiogram, and electrocardiogram. The subjects will be tested at rest, during, and after a submaximal workload on a bicycle ergometer. The statistical analysis will include test-retest correlations to determine the reliability of the measures, correlational and factor analysis (varimax rotation) of the initial (before experimental

treatments) data, and the groups will be matched statistically on the basis of the T-1 measures, using analysis of covariance for adjusting the means and mean squares within on the T-2 and T-3 variables. Two orthogonal comparisons, with the appropriate test of significance, will be made on each variable to determine the effects of (1) training and (2) training with wheat germ oil. (Jack F. Wiley)

2819-7Ø021 Physics. Raman Spectroscopy of Defects in Crystals. The Raman spectra of crystals are to be examined in order to obtain information on the frequencies and symmetries of local modes and resonance introduced in the crystals by defects. Initially, attention will be focused on alkali-halide crystals doped with hydroxyl ions. The computer will be used to provide a: (1) formulation of mathematical lattice-dynamic models to predict the effects of defects on the vibrational spectra of the crystals under investigation and calculation of vibrational spectra based on these models; (2) tabulation and analysis of the experimental data; and (3) comparison of experimental results with the predictions of the theoretical models and subsequent refinement of these models to bring theory and experiment into closer agreement. (M. V. Klein)

2820-7Ø22 Nuclear Engineering. Modification of DTF IV Code (A Los Alamos S_n Transport Theory Code for One-Dimensional Reactors). A one-dimensional S_n neutron transport theory code (DTF 4) obtained from Los Alamos Scientific Laboratory will be modified for operation on the IBM 7094 and 360 computers. The regular and adjoint fluxes generated from the above code will be used as weighting functions for collapsing cross sections. The collapsing formulas were derived by a variational analysis. (J. S. Philbin)

2821-7Ø23 Computer Science. Typesetting by ILLIAC III. A simulation of the problems arising in computer typesetting on ILLIAC III will be carried out. In particular, justification, hyphenation, editing and complex page formatting problems will be examined. Combinations of various interword and letter spaces will be tested to find the optimum method of justification. It is proposed to use pointers in order to reference text when in the editing mode. A possible method of hyphenation would be to slightly decrease or increase the point-size of the font in use thus affecting the length of the line without changing the appearance of text to a reader. (S. J. Flowerdew)

2822-7Ø024 T Materials Research Laboratory. Absorption by Excitons in an Electric Field. Numerical solution of the hydrogenic atom in an electric field with application to absorption by excitons in an electric field will be performed. (Daniel F. Blossey)

2823-7Ø028 Physics. F-Center Calculation. The wave function of the F-center will be calculated both for the ground and first exited states. This will be done by solving numerically the Schrödinger equation with the pseudo-potential or the model potential to obtain the smooth pseudo-wave function. (Igor Abarenkov)

2824-7Ø033 T Chemistry and Chemical Engineering. Nonideal Mixing in Chemical Reactors. This research problem is primarily a theoretical study of nonideal mixing in chemical reactors. Mathematical models are formulated that approximate the extremes in mixing that occur in chemical reactors. Depending on the physical situation studied; algebraic, integral, partial differential, ordinary differential, and integro-differential equations are obtained from the theoretical analysis. The numerical solutions of these equations using experimentally determined parameters available in the literature will give limits on the transient and steady state behavior of real reactors. (S. A. Vejtasa)

2825-7Ø034 Education. Generalizability Study of Correlations Between Universe Scores. A technique is being devised to estimate correlations between universe scores, that is, mean scores over all admissible observations, using the basic approaches suggested by generalizability theory. Components of variance and covariance are extracted using programs developed by the investigator. The data are contrived. The results will provide illustrative models in a paper being prepared for publication. (Travers)

2826-7Ø035 T Chemistry and Chemical Engineering. The methods of X-ray crystal structure analysis are being used to investigate the molecular structure of a series of related compounds. Studies are proposed on phosphonitrilic compounds which contain six-membered rings of alternating phosphorous and nitrogen atoms. The methods being used include the heavy atom method and the direct phasing approach. Programs being employed are principally calculation of structure factors, evaluation of Fourier series, and least squares refinement. (Brian Faught)

2827-7∅036 Psychology. Test Anxiety and Social Reinforcement in Children. The research project is a continuation of previous research in two related areas, test anxiety and social reinforcement with children. The research on test anxiety involves experimental studies of processes believed to mediate the interfering effects of test anxiety, e.g., fear of failure and caution. Research on social reinforcement focuses on experimental studies of factors determining the tendency for children to respond more to adults of the opposite sex than to adults of the same sex as the child. The major computer analyses will involve the SSUPAC programs for Pierson correlation and for analysis of variance. The results will be published in psychological journals if the results warrant professional consideration of the research. (Kennedy Hill)

2828-7∅037 Sociology. The American Image in Western Europe and Japan. The problem under investigation is: how does the internal domestic relations of the United States (more specifically, our treatment of Negroes) affect our image in the countries of Western Europe and Japan. We will be looking at the overall effects of our treatment of Negroes by country as well as the differential effects due to the socio-economic background of the foreign respondents. A secondary topic is the investigation of racism in these countries. We would like to find out in what elements of the population racist attitudes are held and how they differ from country to country. The data used for this analysis comes from a United States Information Agency Study done in England, France, West Germany, Italy, and Japan. It was completed in 1964 and declassified during the summer of 1966. (Sidney Kronus)

2829-7∅040 T Chemistry and Chemical Engineering. Optimum Boundary Control of Distributed-Parameter Hyperbolic Systems. This problem involves the study of the optimal boundary control of plug-flow tubular chemical reactors. In general, the results will be applicable to any first-order hyperbolic system in which control decisions are possible only at the boundaries. Theoretical handling by the methods of variational calculus yields a distributed-parameter two-point boundary value problem which must be solved subject to certain necessary conditions of the Pontryagin type. Methods which can be used to solve such problems include gradient methods, quasilinearization, and invariant imbedding; all of which provide for some type of iterative scheme which generates a sequence of convergent approximations to the problem solution. (H. W. Smith)

2830-70041 Education. Educational Analysis - South Dakota. This study is a factor analysis of variables of school systems and socio-economic characteristics of a sample of counties in South Dakota. The problem involves obtaining least squares solution or rate of change of educational, economic and sociological characteristics of communities over time; and the application of factor analysis to identify a set of variables which best describes the characteristics of school systems. The data were obtained from two sources: the U. S. Bureau of the Census, and from field surveys. (W. P. McLure)

2831-70042 Mechanical Engineering. Radiative Transfer in Non-Gray Gases. A significant problem of current technological interest is that of radiative transfer within real gases. The wave length dependence of non-gray media presents formidable difficulties in radiative transfer calculations. Even with high speed digital computers, it presently appears that the computation time required to exactly compute heat transfer which accounts for such phenomena is prohibitive. The purpose of this effort is to utilize some approximate methods of calculation to investigate the influence of real gas effects on radiative transfer and attempt to assess the accuracy of such methods. Inasmuch as the governing equations are non-linear intro-differential equations, numerical methods must be employed. These calculations would be prohibitive without the aid of the digital computing facility. (R. G. Hering)

2832-70043 Mechanical Engineering. Monte Carlo Methods in Radiative Transfer. Monte Carlo methods have recently become attractive as a means of obtaining numerical solutions to significant problems in radiative transfer. The purpose of these calculations is to apply Monte Carlo methods to problems to which solutions are already available by other means and thereby assess the usefulness of such methods in radiative transfer calculations. (R. G. Hering)

2833-70044 Student Counseling Service. Kuder Profile Patterns. This study investigates by means of multiple discriminant analysis differences in Kuder Profiles among students in mathematics, accounting, and electrical engineering. (P. Schroeder)

2834-7∅045 Agronomy. Analysis of Agronomic Data - 360. The statistical analysis of research data from many projects in the Agronomy Department is one of the service responsibilities of the Agronomy Statistical Laboratory. In order to hasten the transition from the IBM 7094 to the IBM 360, it will be necessary to convert the 7094 program library to FORTRAN IV for the 360. During this conversion several modifications will be made to the programs to increase their generality, flexibility, and usefulness. The new programs which result, will be available for use to all research staff in the department, and will be made available to others on the University staff as the occasion arises. Approximately 70 programs for analysis of variance, regression and correlation, multivariate analysis, and various miscellaneous statistical techniques are involved. (Carmer)

2835-7∅046 United States Geological Survey. Flood Flows from Small Drainage Areas. In the past few years considerable progress has been made in the development of hydraulic principles of flood flows through culverts. These principles may be applied to culvert design with a view of obtaining required hydraulic effectiveness at minimum cost. However, the required hydraulic effectiveness is, in part, a function of the maximum rate of discharge at the culvert site. In order that these principles of design may be effectively applied, data concerning the magnitude and frequency of floods from small drainage areas in Illinois have been collected. It is the purpose of this problem to utilize these data to develop a mathematical model for estimating floods of given return periods. The data will be correlated, by multiple-regression techniques, with physiographic and hydrologic parameters of the watersheds. (Davis W. Ellis)

2836-7∅047 Psychology. Content-Context. The purpose of this study is to investigate the behavioral effects of work role treatments on work behavior. The data will be collected from subjects in an experimental procedure. The data will be analyzed using analysis of variance and correlation and regression analysis. The results will be employed to increase our understanding of the dynamics of work behavior. (George B. Graen)

2837-70048 Psychology. Program Conversion Project. The purpose of this project is the revision and adaptation of existing programs brought here from the University of Iowa. These programs are written in FORTRAN IV. I want to adapt them to the 360 system. The programs are primarily data analysis and parameter estimation schemes for various mathematical models of prediction behavior in young children. Test runs using data gathered from 4 and 5 year old subjects will be used for debugging purposes. There are also some new data which may also be run. The results will be used primarily for ascertaining the adequacy of the new programming. (R. S. Bogartz)

2838-70050 T Chemistry and Chemical Engineering. Chemical Reaction in Nonsimilar Laminar Boundary Layers. This problem involves the study of heterogeneous and homogeneous nonisothermal reactions occurring in laminar boundary layer flows for which the concept of similarity is not applicable. The theoretical analysis of this type of problem leads to nonlinear, second order, partial differential equations that are boundary value problems. These partial differential equations describe the velocity, concentration, and temperature profiles within the boundary layer. The solution of the equations will be sought by implicit finite difference techniques. (R. C. Lindberg)

2839-70051 Engineering Administration. Attrition Study for Engineering Students. A study will be made to determine what percentage of the entering engineering students can be expected to graduate within eight semesters, what percentage will graduate in nine semesters, what percentage in ten semesters, and what percentage will not graduate at all. Also to be studied is the correlation of expected graduation time and status at entry to the College of Engineering (i.e., transfer from other college, new freshman, transfer from Chicago Circle Campus, etc.). (Etnyre)

2840-70052 Agricultural Economics. Economic Analysis of Water Use in Illinois Agriculture. Estimates will be made of the change that occurs in average returns per acre of corn when irrigation is adopted. Estimates of the change in year-to-year variations will also be made. The sources of corn-yield data will be both commercial farm yields and experimental yields. Temperature and rainfall data will be used to explain corn yield variation and to form the basis for expected yields under irrigation. The principal statistical techniques used will be multiple regression, with corn yield

as the dependent variable and management practices, temperature, and rainfall as independent variables. By adjusting the rainfall variables to those levels corresponding to the highest observed yield, an estimate can be made of the yield increase. Use of available cost data will permit calculation of increased returns and their variation. (E. R. Swanson)

2841-70053 Accountancy. Simulation Research. Theoretical explanation of system errors in simulation experiments will be examined. Parameters of simulation experiments will be changed to determine sensitivity to the system. GPSS 360 will be used. (Richard Nolan)

2842-70054 Horticulture. Flower Market Grades for Roses. Nature of problem: quality factors which influence the development of grade standards for cut roses. Data will be obtained by weekly measurement of quality factors of commercially produced roses. Correlations will be determined between quality factors. Distribution of roses by trial standards developed will be computed. Computer results will be used to develop the trial standards and to measure their usefulness. (J. R. Culbert)

2843-70055 Statistical Service Unit Administration. Statistical Processing for Administrative Research. This problem uses the available Compilers/Library, and the SSUPAC system to generate statistical reports as requested. Data are obtained from student records and student surveys by various administrative agencies of the University and brought to Statistical Service Unit, Administrative Research section, for statistical processing. The computer results are used by these agencies in arriving at decisions, formulating policy and preparing reports. (C. R. Thomas)

2844-70056 T Electrical Engineering. Radiation Patterns of Frequency Independent Antenna. The object of this problem is to find the radiation patterns of a vertically polarized log-periodic array composed of driven and parasitic monopoles over a ground plane. This will be used in conjunction with an experimental model to obtain maximum directivity and gain while maintaining frequency independent characteristics over a specified bandwidth. Theoretically, the active region of the log-periodic antenna at one frequency can be represented by an end-fire couplet (for the driven elements) and two side monopoles acting as parasitic elements. By numerical integration

techniques the mutual impedances between these elements can be calculated, and from this the E-field radiation patterns may be determined at each frequency. These theoretical results will then be compared to the radiation patterns obtained from the experimental model on the ground plane antenna test range. (William Habicht)

2845-70057 T Materials Research Laboratory. Radiation Damage in Gold. Pure gold specimens were irradiated with 3 Mev. electron beam at liquid nitrogen temperature. Isothermal and isochronal annealings were done to these specimens up to +130 degree Centigrade. Standard potentiometric methods were used to measure resistivities during the annealings. The data are being analyzed using slope change method and Primak Analysis to obtain activation energies at stage III. Also the determination of the order of kinetics at various temperatures is under way. Numerical integrations are to be performed by either Simpson or Gauss' quadrature methods for the Primak analysis and least square method will be used for the curve fittings. (Lee)

2846-70058 Theoretical and Applied Mechanics. Optimization of Structural Shapes. Optimum design of structural shapes, within the limitations imposed by defining equations with four or with six parameters, is being investigated. These shapes are used for various clamped plates, closed shells of revolution, shells of revolution of one sheet and of two sheets and hydrodynamic shells configurations for undersea vehicles and structures. Deformation behavior is established using the Ritz energy method and in some cases the methods of collocations and of complex variables are employed. (W. J. Worley)

2847-70059 Geology. Stress-Strain Calculations in Experimental Rock Deformation. In the field of experimental rock deformation, stress, strain, and deformation rates during a test must be determined from recorded values of applied load, piston displacement, and elapsed time. Although the equations involved in these conversions are relatively simple, they must be executed many times for each test. A FORTRAN IV/7094 program for this purpose is being modified to include a CCPLOT subroutine to draw standard and normalized stress-strain curves. Interpolated values of stress and strain will also be calcuated and punched on cards for further computations. (Fred A. Donath)

2848-7ø060 Geology. X-ray Analysis of Mineral Structures. X-ray analysis of the atomic structures of mineral involves extensive amounts of computing and data processing. Atomic structures of micas and carbonates are currently being our special field of investigations. The computer portion of the problem will cover: (1) intensity calculations of 3-4 thousand reflections; (2) Fourier transforms of the calculated intensity data; and (3) least-squares refinement of atomic parameters by correlating observed and calculated ideal intensity values. Programs for the above computations are partly already available and will be partly developed by us. (Necip Guven)

2849-7ø063 T Psychology. Role Distortion in Personality Questionnaires. Psychological research over the past two decades has indicated that a considerable amount of variance in personality questionnaires is attributable to non-content sources. Previous investigations have pointed out the important, but contaminating, influence of such variables as social desirability, response styles, test strategies, etc. The present research is designed to examine simultaneously the interactive influence of other personality variables and role involvement in questionnaire distortion. Subjects in the study have taken the <u>Sixteen Personality Factor Questionnnaire</u> four times each in situations designed to elicit the types of behavior common in four different situations, such as a standard, experimental situation, a job-seeking situation, and so forth. In addition, short, motivational scales were administered in an attempt to assess the degree of role involvement. Scores on the sixteen personality dimensions will be intercorrelated and the resulting correlation matrix factored. The final rotated solution should indicate the loadings of the true, common factors on each of the personality and motivation variables. Inter-situation differences that appear should indicate the extent to which a particular situation moderates the configuration of test results and the interactive influence of other personality dimensions. (Krug)

2850-7ø064 Recreation. Special Projects in Research on Leisure Behavior. The problem involves a number of graduate-level research projects designed to investigate the determinants and effects of leisure behavior in a variety of settings (e.g., a classroom for retarded children, a day camp, a specific game setting). Computer analyses will include descriptive statistics as well as inferential statistical analyses on comparative groups (such as t-tests, chi square, analysis of variance). (Doyle Bishop)

2851-7Ø065 Recreation. Survey Studies of Recreation. The problem involves survey analyses of various Illinois communities in order to investigate how the residents use their leisure time, frequency of participation in recreation activities, and attitudes toward available recreation facilities and opportunities. Data analysis will focus on descriptive statistics (e.g., means, correlation coefficients) and some multivariate analyses of questionnaire items (e.g., factor analysis). (G. Lowrey)

2852-7Ø066 Plant Pathology. Field Corn Disease Research. This research project involves testing of stalk rot and leaf blight in hybrids. It also is concerned with developing resistant lines, inbreds and hybrids to the above diseases. In this connection, lines, inbreds, and hybrids will be tested in replicated trials and analysis of variance will be used to test if there are differences. Plants will be rated as to their disease resistance. (Hooker)

2853-7Ø067 Geology. Stress-Strain Calculations in Experimental Rock Deformation. In the field of experimental rock deformation, stress, strain, and deformation rates during a test must be determined from recorded values of applied load, piston displacement, and elapsed time. Although the equations involved in these conversions are relatively simple, they must be executed many times for each test. Interpolated values of stress and strain will also be calculated and punched on cards for further computations. (Fred A. Donath)

2854-7Ø068 Microbiology. Enzyme Kinetics. Kinetic parameters of several enzymes will be computed and statistically analyzed. The activity of enzymes as a function of concentration of substrate, coenzyme, and inhibitor will be estimated using chemical methods. The values obtained will be subjected to least squares regression analysis to determine which values should be discarded. The results, in terms of K_m (Michaelis-Menten constant, expressing the substrate concentration required for half-maximum velocity) and V_{max} (the maximum velocity) will be employed in attempts to define the characteristics of the enzyme active site. Subsequent similar analysis in the presence of certain competitive and non-competitive inhibitors will be used for finer analysis of the enzyme active site. Using enzymes from different biological sources and using enzymes which catalyze different reactions of the same substrate, further analysis of the enzyme active sites will be made to determine the relative degrees of homology between enzymes. (R. D. Demoss)

2855-7Ø069 Horticulture. Department of Horticulture Research Projects. The Department of Horticulture has employed one person to do the programming for all of the faculty; therefore, this problem number will be used for a variety of projects. (Snodgrass)

2856-7Ø070 Civil Engineering. Oxygen Diffusion. A tracer is being used in laboratory experiments to obtain vertical concentration gradients in turbulent water. From these gradients, vertical diffusion coefficients are calculated by finite difference techniques. Particular attention is being given to diffusion in the surface film region in the oxygen absorption process. Turbulence measurements are also to be made in the film region of open channel flow. These measurements will be digitized and analyzed statistically. (E. R. Holley)

2857-7Ø072 Theoretical and Applied Mechanics. Abnormality Detection in Cerebral Circulation. Various abnormalities in the circulatory system alter the impedance characteristics of the arterial network. The computer will be used to determine the impedance changes in the network caused by a number of these abnormalities and by their placement in the system. Impedance predictions can be made theoretically by solving a series of first order algebraic equations; since impedance is desired over a frequency range, this series of equations must be solved for each frequency. Data will be limited to a few system constants set by the network geometry. In addition to solving this series of equations, data received from the heart pulse wave of a physiological specimen must be broken into its Fourier components in order to be able to correlate experiment and theory. (M. E. Clark)

2858-7Ø073 Theoretical and Applied Mechanics. Non Linear Flutter. Nonlinear oscillations of a viscoelastic cantilever beam subjected to an inclined follower force are investigated. This system is modeled by two coupled partial differential equations of fourth order. These are solved numerically by a finite difference scheme of the Crank-Nicholson type. Amplitudes, frequencies, and conditions resulting in flutter are sought. (J. C. Wiley)

2859-7Ø074 Theoretical and Applied Mechanics. Numerical Integration Using the Field Method. Study of uses and possible extensions of applicability of the field method for numerical integration of two-point boundary value problems. The method alters the character of certain types of linear differential equations in such a way as to make the numerical integration insensitive to length of the interval. This avoids the exponential buildup present in some solutions. (R. E. Miller)

2860-7Ø075 Home Economics. Hatch Home Economics Study on Use of Pest Controls. A study of Illinois Consumers' Reactions to Use of Pest Control on Agricultural Products--the overall objective is to obtain insight concerning the Illinois consumers' knowledge of, attitudes toward, acceptance of, and demand for agricultural products subjected to varying degrees and alternative methods of pest control. Specific objectives of the project are as follows: For a representative sample of consumers: (1) to study the relationship between knowledge of and attitudes toward the use of agricultural products subjected to pest control; (2) to study not only attitudes but also the strength of these attitudes toward the use of agricultural products subjected to pest control; (3) to study the relationship between knowledge of and acceptance of the use of agricultural products subjected to pest control; (4) to study the relationship between attitudes toward and acceptance of the use of agricultural products subjected to pest control; and (5) to study the relationship between attitudes toward and demand for agricultural products subjected to pest control. The method of analysis of data will be multiple linear regression. In one instance, the dependent variable will be knowledge and the independent variables will be the socio-economic characteristics of the households surveyed. In another instance, the dependent variable will be total attitude and the independent variables will be the socio-economic characteristics of the households and total knowledge. The sample consists of 704 usable family records. The Federal Government is very concerned with determining people's attitudes toward agricultural products subjected to pest control. It is anticipated that the information from this study will be used to determine educational programs and legislative action. (Dunsing)

2861-7Ø076 Nuclear Engineering. Neutron Pulse Propagation. This research involves a study of how the neutron energy spectrum approaches equilibrium when neutrons from a nuclear reactor are injected into a moderating material. The energy-time dependent Boltzmann equation is solved using standard numerical methods involving the solution of a complex matrix and several expansions in orthogonal functions. (G. H. Miley)

2862-7Ø078 Civil Engineering. Analysis of Structural Safety. The probabilistic studies of structural safety made thus far have concentrated on the evaluation of the probability that the system will pass to a "failed-state." For obvious reasons, in practice, the probability of failure must be small. Small probabilities of failure require extrapolation of the available data beyond a range where it is no longer possible to state confidence limits on the computed results. It is therefore proposed to study the factor of safety rather than the "failed-state" within a probabilistic context. The requested computer time is to explore this possibility using several distributions. Consideration will be given to structural members as well as structural systems. (M. Amin)

2863-7Ø079 T Mechanical Engineering. Non Linear Partial Differential Equations for the Secondary Flow. The electric wind phenomenon appears in the case of a high potential corona placed at the center of a rectangular channel. Both top and bottom sides of this channel are horizontal and made of conductive material which is at zero potential. The equations to be solved are the first perturbation of the mass flow general equations of motion. Because of the nonlinearity of the equations the method of relaxation is used. The prime component of velocity is assumed and several iterations may be needed to end with approximately the same value that has been started with for an accuracy of .00005. (O. E. Ramadan)

2864-7Ø080 T Electrical Engineering. Numerical Solutions to Differential Game Problems. In this problem, numerical examples of simple two-party optimal control problems or differential games will be solved. It is hoped that solving specific problems will suggest methods for solving more complex problems. Most of the examples will come from two and three dimension kinematic equations. The mathematical methods used will include solving nonlinear differential equations of the Riccati type and finding optimal solutions by the use of dynamic programming. (Patrick Shea)

2865-7∅081 Civil Engineering. Stability Problems in the Hydrologic System. The method of characteristics for the specified time intervals will be used to solve the equations of continuity and motion for the velocity and depth of free surface flow in a watershed. The instability of response caused by the prescribed boundary and initial conditions as well as the surface roughness will be investigated. (S. J. Kareliotis)

2866-7∅082 Theoretical and Applied Mechanics. Hemodynamics. The hemodynamics of the cerebral circulation is being studied with the aid of computer models. Problems such as fluid impedance variation with frequency in flexible vessel networks due to configuration changes (such as looping and branching), loading changes (both efferant and afferent), and internal changes (such as abnormality inclusions) are being studied. Hydraulic transmission line theory is the main analytical tool being used. For some of the problems simultaneous sets of non-linear equations need to be solved and routines like UTR3 are being adapted for this purpose. Another phase of research involves the analysis of physiological circulation data. The pressure- and flow-time records from animal tests must be converted to digital form so that Fourier analyses can be made in the computer. Impedance-frequency calculations can then be made which allow comparison of experimental and theoretical results. The A-D conversion facility of the DCS will be used. (M. E. Clark)

2867-7∅083 T Theoretical and Applied Mechanics. Numerical Determination of Kernel Functions. The creep response of materials subjected to a history of multiple stress reversals can be described by a hereditary functional. This functional is easily expanded in a series of multiple integrals the kernel functions in this expansion depending on the particular material. It is proposed that the first three terms in this series be kept, thus requiring the determination of three kernel functions. Torsional creep tests will be conducted on tubular specimens to determine the creep response of several materials. The response will be described analytically (e.g., a polynomial fit), this description in turn being used to determine the kernel functions. Subsequently, the torsion problem will be solved for the solid circular shaft using the series expansion of the hereditary functional. Several different loading histories will be used to check the theory. (P. A. Lilienthal)

2868-7Ø084 T Civil Engineering. Shock Pressures Due to Breaking Waves. The impact of water waves upon structures built near a shoreline where the waves break has been observed to result in pressures much higher than would normally be expected. The resulting high pressure, or shock pressure, is distributed in some fashion over the vertical face of the structure. The analytic determination of this distribution is to be attempted using a finite difference solution to the wave equation for the propagation of pressures using simplified boundary conditions for the equation. This equation is a linear, second-order, partial differential equation in three independent variables (two space coordinates and time). The boundaries include a free surface and two rigid boundaries, one of which is the test structure itself, the other being the bottom of the wave tank. Initial computations will assume a horizontal free surface. If the results of this investigation prove satisfactory, a more complicated free surface geometry will be investigated which will more closely simulate the actual profile of a breaking wave. In addition, the experimentally determined pressure distributions will result in large quantities of data which can best be processed by computer. (J. R. Weggel)

2869-7Ø085 Civil Engineering. Dynamic Response of Plastic Radomes. The program developed for this project will determine the dynamic response of plastic radomes subjected to nuclear or high explosive blast loads. The radomes analyzed are thin shell structures composed of a hemispherical dome joined to a cylinder. The shell is made of a laminated material which is assumed to display orthotropic elastic material properties. (T. O. Blackburn)

2870-7Ø086 Physics. Dysprosium Eigenvalue and Equation of State Calculation. The equilibrium magnetic configuration for antiferromagnetic dysprosium in applied dc and rf magnetic fields is to be determined in a 0°K approximation. The minimization yields a system, $\Phi = 0$, of non linear algebraic equations of the form:

$$\Phi_i = \alpha[\sin(\varphi_i-\varphi_{i+1}) - \sin(\varphi_{i-1}-\varphi_i)] + \beta[\sin(\varphi_i-\varphi_{i+2}) - \sin(\varphi_{i-2}-\varphi_i)]$$

$$+ \gamma\sin(\varphi_i+\varphi_o) = 0$$

(φ_i is the angle between the ith moment and the applied dc magnetic field.) These equations are solved using Newton's method for a system of non-linear equations. Knowledge of the field dependence of the state of the system enables a calculation of the resonant frequencies of the system. Commutation of an angular momentum operator with the Hamiltonian yields an eigenvalue equation involving a 5 x 5, 6 x 6, or 26 x 26 matrix. Francis' Q-R algorithm is used to compute the eigenvalues of these matrices. The results will be compared to published magnetization and magnetostriction data and analyzed with respect to dynamic effects observed in a microwave spectroscopy experiment on dysprosium single crystals. (H. A. Blackstead)

2871-7∅087 Institute of Labor and Industrial Relations. Railway Employment Analysis. Standard regression programs are used to examine the goodness of fit of several alternative employment projection models to the data on employment in U. S. Class I railroads during the post-World War II period. The data were obtained from the Interstate Commerce Commission reports and the results of the regression coefficients will be utilized to project employment for the U. S. railroads over the period 1964 to 1970. (Adolf Sturmthal)

2872-7∅088 Agricultural Economics. Regional Economic Development. The project will assess and predict agricultural and economic changes occurring in a selected region of rapid economic development. Mathematical tools used for analysis will include multivariate analysis and restricted maximization models. Data was obtained through both survey and secondary sources (census type data). Computer results will be used as a basis for the analytical analysis of regional economic development. (Scott)

2873-7∅089 Institute of Government and Public Affairs. Illinois Executive Study. The Illinois Executive Study, conducted by the Institute of Government and Public Affairs, is designed to identify career histories, educational and occupational backgrounds, and work-connected attitudes of persons in upper-level positions of administrative responsibility within the Illinois state government. This interest stems from a conclusion that such persons constitute an important decision-making elite on matters of state policy, and from the total lack of any information about them. It is assumed that knowledge about the social and educational backgrounds of

such people, their career lines within state service, and their professional orientations will allow saying something useful about the nature of the state bureaucracy considered as a whole, the nature of the various sub-units within the state bureaucracy, and the relationship between this bureaucratic elite and the state political system. The data were obtained from mailed questionnaires completed by 974 Illinois executives. The respondents were defined by income level rather than functional performance. Cross-tabulations, rank-order correlations, and product-moment correlation techniques will be used in the analysis of the data. The computer results will serve as the basis for several journal articles, and as material for a background paper for the Illinois Assembly on Manpower for Illinois Governments. (Joe P. Pisciotte)

2874-7Ø090 Institute of Government and Public Affairs. Illinois Federal Aid Study. The Illinois Federal Aid Study is being sponsored by the Institute of Government and Public Affairs. The study grows out of recent national concern with the fiscal needs of state and local governments and the alternative suggestions that have been made as to how the federal government might help ease the strain of state and local resources. In the course of these discussions, little attention has been given to the important question of how state and local governments would use unconditional federal subsidies, and whether the current federal grant programs have had the impact they were designed to. Any federal distribution of surplus revenues to the states or to local governments will undoubtedly require some distribution standards for the lower governmental units. On the basis of state and local finance data, primarily compiled from U. S. Bureau of the Census data, stepwise multiple regression analysis will be used to determine the impact on Illinois local governments of selected federal grant programs. The same type of analysis will be undertaken to experiment with various intrastate distribution formulas for various types of proposed federal grant programs to determine their effects on local government spending in Illinois, and to estimate the equalization effects of the several programs with respect to the income distribution of the 102 Illinois counties. The results of the research will be incorporarted in a monograph on the topic of intergovernmental finance in Illinois. (Robert P. Fairbanks)

2875-7∅091 Mining, Metallurgy, and Petroleum Engineering. Electronic Structures of Point Defects in Metals. Electronic structures of point defects, such as impurity atoms, vacancies and interstitials, are one of the primary subjects to be studied in this program. In particular, the electric field gradient will be computed on atomic sites neighboring defects, in order that we may clarify the structures of defects on the atomic scale and compare them with experimental results obtained from nuclear magnetic resonance. A table of scattering potentials, calculated by other authors, will be used as input, and values of electric field gradient and some other relevant quantities are to be obtained in the form of numerical tables. The mathematical method involved is essentially a Fourier transformation by Filon's method, with multiple integrals up to four dimensions. (Y. Fukai)

2876-7∅093 T Special Education. Cognitive Achievement Through Independent Study in Summer Programs in Continuing Education. This study is intended to examine in-service training programs which combine independent study in content and group participation in the dynamics of interaction as operational procedure in changing teacher attitudes. Regional institutes dealing with practical problems related to the teacher's actual experience and a campus course on the education of gifted children, may provide different environments for attitude change. The problem is to ascertain the degree of cognitive achievement gained by public school teachers and administrators participating in public school workshops through independent study, from a basic core of knowledge presently available in research findings concerning gifted children. During the summer of 1966, regional and university institutes were sponsored by the Office of the Superintendent of Public Instruction, Department of Program Development for Gifted Children, to provide training for public school personnel in the area of the gifted. Eight regional institutes were sponsored by public school districts or combinations of school districts to serve a particular area of the state of Illinois. Each institute offered a program dealing with interests unique to that institute but with a common base of education for teaching gifted students. A diagnostic test of cognitive achievement in content on gifted was developed. Approximately 340 teachers and administrators were given the diagnostic test of content on gifted plus a test of mental ability and attitude surveys at the beginning of the Summer Institutes on Gifted, and the test of content on gifted and the attitude surveys were administered

again at the end of the summer sessions. Data was collected concerning processes of study and subject emphasis for each workshop group. Statistical procedures are to be used to analyze the data and determine differences in achievement and attitudes among ten groups (eight regional institutes, a university institute, and university course). Adjustment for differences of mental ability and for differences on pre-test scores will be made by analysis of covariance. If a significant difference is found, multiple comparisons will be made to find which groups vary. (Mary. L. Kooyumjian)

2877-7Ø094 Aeronautical and Astronautical Engineering. Solution to Vibration of Stiffened Plates Problem by Finite Elements. The problem is to find the natural frequency and mode shapes of a stiffened panel by the finite element method. For this method, the panel is assumed to be divided into a discrete number of triangular shaped elements for which the mass and stiffness matrices are then derived. These elements are then combined by assuming that the summation of forces at the nodal corner points are zero. Once the mass and stiffness matrices have been obtained for the plate, an eigenvalue/vector problem is formed, the solution of which gives the natural frequency and mode shape. (A. R. Zak)

2878-7Ø095 Honors Program. Perceptual Changes of Honors Students at the University of Illinois. The purpose of this study is to investigate the changing perceptions of James Scholars toward the University of Illinois and the related implications these have for modification of the institutional milieu. The primary instrument to be used to measure the perceptual changes of four entering classes of James Scholars (1967-1970) will be the College Characteristics Index, developed by Stern and Pace. In addition to studying the relationship of the variables of this instrument and the milieu factors, development of scales particular to this group and this institution will be attempted. As the study progresses, other means of gathering data concerning changing perceptions of students will be utilized, such as structured interviews, questionnaires, etc. The computer use will be for correlations, item analyses, factor analyses, variance analyses, and covariant analyses, in addition to simple frequency tabulations and print-outs. (M. Jean Phillips)

2879-70096 Chemistry and Chemical Engineering. X-ray Crystal Structure Analysis. The methods of X-ray crystal structure analysis are being used to investigate the molecular structure of a series of related compounds. Studies are proposed on some molecules related to ferrocene, particularly derivatives where bridging groups give the geometry a certain degree of rigidity. Metal carbonyl complexes of aromatic hydrocarbons are also being studied, particularly complexes with molecules containing seven and eight-membered rings. The methods being used include the heavy atom method and the direct phasing approach. Programs being employed are principally calculation of structure factors, evaluation of Fourier series, and least squares refinements. (I. C. Paul)

2880-70097 T Civil Engineering. Vibratory Pile Driving. The dynamic behavior of piles being driven with vibratory pile drivers is being studied. The mathematical model is a lumped-mass elastic system with non-linear damping. The computer is being used to run parameter studies. These parameter studies are to be the basis for predicting the performance of vibratory pile drivers under a given set of soil-pile conditions. (John Smart)

2881-70098 T Civil Engineering. Conventional Pile Driving. The problem includes the numerical analysis of dynamic behavior of a lumped-mass model. The model mathematically represents a pile driver and a soil-pile interaction during driving. A mathematical determination may be made of stresses, and of pile penetration or permanent set per blow, against any amount or kind of soil resistance. This system will be subjected to a transient force input, i.e., a problem of conventional pile driving. (Jerry Parola)

2882-70099 T Civil Engineering. Stress Analysis of Short Cantilever Beam. Use is made of an existing program to perform the stress analysis of short, deep cantilever beams. The existing program is based on a mathematical model which replaces the continuum by a discrete element model. Thus the partial differential field equations are reduced to a set of linear algebraic equations which are generated within the computer and solved by the Choleski method. The purpose of this analysis is to find the stress distribution in concrete due to bond stresses applied by reinforcing steel on the microscopic level. (M. F. Stocker)

2883-7Ø100 Civil Engineering. Estuary Dispersion. The problem under consideration is that of mass transport in estuary flow where the transport velocity varies in both space and time. Experiments have been made in the laboratory. The digital computer is to be used to perform numerical integration of the three-dimensional mass conservation equation so that the analytical work may be compared to the laboratory experiments. (E. R. Holley)

2884-7Ø101 Chemistry and Chemical Engineering. Vibrational Transfer. This problem is to evaluate numerically certain integrals which arise in commonly used theories of vibrational energy transfer in intermolecular collisions. Standard gaussian quadrature techniques will be used. The results of these calculations will be compared to experimental results to examine critically the theory. (J. T. Yardley)

2885-7Ø102 Dairy Science. Dairy Cattle Management Statistics. Statistical analysis of experiments designed to determine the effect of management decisions and practices on the level of milk production and profit with dairy cattle. Mathematical methods which will be used include correlation, regression, analysis of covariance and linear programming. Data were obtained from the University Dairy Herds. Computer results will be used to estimate the extent of certain practices on the level of milk production and profit with dairy cattle. (S. L. Spahr)

2886-7Ø103 Dairy Science. Genetic and Statistical Research. This problem number will be used to convert present 7094 FORTRAN II programs to FORTRAN IV programs for use on the University of Illinois 360 system. (H. G. Markos)

2887-7Ø104 Dairy Science. Selection for Traits in Which the Variance is Primarily Non-Additive. Simulation of genetic populations under selection, using Monte Carlo techniques, to determine the value of various methods of selection in utilizing non-additive genetic variance. This study will utilize pseudo-random number generators in developing the populations and in simulating the various selection methods. Least-squares techniques will be used to analyse the results. (Peterson)

2888-7Ø105 Mining, Metallurgy, and Petroleum Engineering. Computer Model for Branching Phenomenon in Water Resources Research. A graph theoretical model is used for the representation of branching processes in water resources research. A particular network is considered as a realization of a particular graph (bifurcating aborescences) amongst all possible graphs with a given number of vertices. The pertinent flow laws are then considered as the complete randomness of the graph patterns. In order to test this hypothesis, the computer is used for a Monte Carlo method for generating the Lukasiewicz word for the graph and evaluating the various possible configurations. (A. E. Scheidegger)

2889-7Ø106 Mining, Metallurgy, and Petroleum Engineering. Stresses Around Underground Inhomogeneities. Some problems of the stress distribution around underground features of various geometrical shape have been solved analytically on the basis of the theory of elasticity in two dimensions. The computer is used to obtain numerical results from the rather complex analytical solutions. (A. E. Scheidegger)

2890-7Ø107 Chemistry and Chemical Engineering. Vibrational Transfer. This problem involves the calculation of probability for vibrational energy transfer during gas phase molecular collisions. The basic theory is that developed by Herzfeld, modified to take into account the effects of molecular rotation. The integrals involved cannot be evaluated in closed form and must be integrated numerically. A standard Gaussian quadrature procedure will be used. (J. T. Yardley)

2891-7Ø108 Geology. Exploratory Research. Investigation of quantitative methods for correlating rock strata will be made. Various techniques will be studied; i.e., data smoothing, autocovariance, spectral density, harmonic analysis, and trend analysis. The data are mainly qualitative field descriptions of the rocks that have been quantified for this work. (C. John Mann)

2892-7Ø111 T Chemistry and Chemical Engineering. Crystallographic Investigation of Some Picryl Ethers. The methods of X-ray crystal structure analysis are being used to investigate the molecular structure of a series of benzophenone picryl ethers. The study will be directed in particular toward

the relationship of structure to solid state reactivity. The methods being used include the heavy atom method and the direct phasing approach. Programs being employed are principally calculations of structure factors, evaluation of Fourier series, and least squares refinements. (D. Y. Curtin)

2893-70112 Agronomy. Micronutrient Survey. Plant Analyses Nutrient Study: The plant takes up the greater proportion of thirteen essential elements from the soil and the nutrient composition of plants can be a useful indicator of the status of the essential soil nutrients. Present soil testing techniques have not yielded useful information concerning the soil status of micronutrients as they have for P, K, Ca and Mg. The data obtained in this survey can be a useful indicator of the micronutrient and macronutrient status of many Illinois soils. The soil test data and soil type criteria will provide useful correlation factors for studying the factors affecting the nutrient status of the plant. As this kind of information has not been previously obtained it will be a useful bench mark for comparison with surveys at future dates. (Aldrich)

2894-70113 Computer Science. Fixed Field Alternating Gradient 10-30-67. A fixed field alternating gradient accelerator made up of super-conducting strips will be approximated by appropriately placed bundles of straight wires. The field configuration will then be mapped. (J. N. Snyder)

2895-70114 T Electrical Engineering. Ionospheric Electron Density. This 360 computer time is to be used to convert existing programs operating under problem specification number 29003 and defined there from 7094 operation to 360 operation. (H. D. Webb)

2896-7N001 Natural History Survey. Waterfowl Migration. The files of the Natural History Survey contain records for the past 22 years of weekly censuses of waterfowl in the Illinois and Mississippi River valleys, made from light aircraft. Weekly censuses are supplemented by observations of flights of waterfowl, made by experienced observers in the same area. For each of 70 locations, the weekly censuses give the numbers of waterfowl of each of 14 species for a 2 to 3 month period in the fall and for lesser periods in spring. The first objective of the research is to analyze the

data to obtain parameters describing the pattern of migration in time and area. This will be done by finding the frequency distribution of waterfowl arrivals and departures each year by comparing numbers observed in successive censuses; combining data for species which do not differ significantly among themselves; computing the mean times of movements for groups of species and for different geographical locations; finding the deviations from the mean for each year. Plots of the times and magnitudes (both numbers and percent of total seasonal flight) of waterfowl arrivals and departures will be made. Following analysis of the waterfowl data, weather parameters believed to affect the initiation of migration will be developed from U. S. Weather Bureau records, and a multiple linear regression calculated between waterfowl migration parameters and the selected weather parameters. Results will be used to identify the weather factors most important to waterfowl migration, and to predict times and magnitudes of future migration waves in the Mississippi Flyway. (Wm. J. Francis)

2897-7N002 T Electrical Engineering. Scattering by Two Spheres. The problem of scattering by two spheres is analyzed by using: (1) a modified geometric theory of diffraction; (2) an iteration method for the current distribution; and (3) the translation addition theorem for vector spherical wave functions. All these methods yield eventually the field scattered by two spheres which is used for radar cross-section and related studies. (John H. Bruning)

2898-7N003 T Aeronautical and Astronautical Engineering. Inverse Airfoil. The maximum lift which may be carried by a mono-element airfoil is to be determined. This requires the specification of a pressure (and hence velocity) distribution about the airfoil. This pressure distribution is then used as an input for a numerical integration scheme to determine if the proposed pressure distribution corresponds to an airfoil, and what the airfoil shape actually is. (Robert H. Liebeck)

2899-7N004 T Chemistry and Chemical Engineering. Flames and Combustion Studies. The present problem involves the studies of the dynamics of boundary layer flames. The main interests are the predictions of extinction and stability of the system. The system consists of a stream of combustibles impinging on a flat plate to form a stagnation flow. A flame is set-off in the boundary layer. Parameters are then varied to extinct the flame. This system can be simulated mathematically by solving the equations of change, and a numerical method is necessary to achieve a solution. (Ming Fang)

2900-7N005 T Mechanical Engineering. Low Density Hypersonic Slip Flow. An analytical study is being made of the flow of rarefied gases past two-dimensional slender bodies. The method of solution involves a control volume approach, in which velocity and temperature profiles are assumed and computer calculations determine if the assumed profiles satisfy continuity, momentum and energy requirements. An iterative procedure is then employed which yields solution values which satisfy the conservation principles. (R. E. Eilers)

2901-7N006 Civil Engineering. A Problem Oriented Language for Solving Continuum Problems. The Discrete Model Technique of solving problems in solid mechanics has proven to be a very powerful tool. Investigators have used the method to solve problems involving the static or dynamic response of systems which exhibit both geometric and material non-linearities. A continuing drawback has been that each investigator must generate a complex computer program to solve a particular class of problems. The purpose of this investigation is to develop a Problem Oriented Language for solving complex problems with the Discrete Model Method. The availability of this language would allow future investigators to devote their time primarily to the formulation of problems and their corresponding solutions, rather than on the computer program required to obtain the solutions. (L. Lopez)

2902-7N007 Electrical Engineering. Semiconductor Physics and Devices. Theoretical calculations are made on the quantum mechanical properties of semiconductors, such as energy bands, carrier scattering probabilities, energy states of localized defect states, electron and hole capture probabilities at the localized states and others, and on the phenomenological and electrical characteristics of semiconductor devices such as the static and dynamic characteristics at low and high frequencies of p-n junctions, junction transistors, field effect transistors, optical devices and so on. (C. T. Sah)

2903-7N008 Home Economics. Developmental Correlates of Treatments for Culturally Disadvantaged. The study involves three interdependent aspects: (1) investigation of parental attitudes with respect to behavior of disadvantaged; (2) specification of "modeling" upon identification and competency; and (3) cognitive gains as a function of treatment. Analyses include: (1) correlation; and (2) ANOV for (a) relation among variables and (b) treatment effects. (L. Van Den Daele)

2904-7N009 T Electrical Engineering. Interface and Bulk Phenomena in Solid State Physics. Electronic properties of the insulator-semiconductor interface and the bulk in semiconductor materials are investigated under this problem title which includes detailed studies of the orientation effect of the semiconductor substrate on the interface state concentration and evergy level, the fixed oxide charge density, the interface 1/f low frequency noise and surface scattering of electrons and holes. These problems require a considerable amount of numerical calculation of both the theoretical analysis and of the experimental measurements. The methods involved in the mathematical calculations include the simple algebraic operations, numerical integrations of closed integrals and solutions of differential and integral equations. The input data are obtained either from theoretical considerations of the problem on hand or from the experimental measurements obtained in the laboratory. The theoretical computer results will be used to guide experiments and the calculated experimental data from the computer results will be compared with the theoretical calculation. (C. T. Sah)

2905-7N010 Zoology. Computer Taxonomy. This problem consists of experimenting with various mathematical procedures for processing character data in numerical taxonomy. (Eades)

2906-7N011 Electrical Engineering. Aeronomy Parameters. One of the important parameters related to the control of ionization in the inosphere by solar radiation is the solar zenith angle. This angle is easily calculated from data contained in the American Ephemeris and Nautical Almanac, but the calculations are tedious when many cases must be examined. A FORTRAN IV program which gives the solar zenith angle, shadow height, and other parameters is now operational. This program and several similar ones involving aeronomic parameters are the scope of problems included in this request for a problem specification number. (Mechtly)

2907-7N012 Electrical Engineering. Satellite Ephemeris. The research is concerned with the study of the ionosphere using radio signals from artificial earth satellites. The subject of experimental research can be divided into three parts. These are (1) the investigating of the columnar electron content of the ionosphere and the exosphere by observation of the Faraday rotation of the satellite radio beacon signals and Doppler shifts

of the frequencies; (2) the investigation of traveling ionospheric disturbances from observation of large-scale irregularities in the columnar electron content at spaced stations; and (3) the investigation of small-scale ionospheric irregularities by means of scintillation of radio beacon signals. The theoretical research can be divided into three parts. These are (1) wave propagation; (2) physics of formation of ionospheric irregularities; and (3) aeronomy of the ionosphere and the magnetosphere. (K. C. Yeh)

2908-7N013 Bureau of Community Planning. Metropolitan Models Sequence. The purpose of this ADP project is to "computerize" an illustrative analytical system for comprehensive metropolitan plan-making. The system in question is being developed by the senior investigator to illustrate the role of mathematical techniques and automatic data processing in urban planning practice. It will be produced as a training manual for classroom use in UP 376 (Planning Analysis) and in continuing professional education courses. When completed it will comprise an integrated sequence of planning agency tasks, a set of computer programs for performing these tasks and a small pool of input data which represent conditions in a hypothetical medium-sized metropolitan region. The tasks will provide examples of such basic analytical procedures as estimation, prediction, prescription and calibration. They will entail a variety of mathematical models ranging in complexity from simple empirical presumptions to input-output, linear programming, and regression-based relationships. The ADP program as such will utilize the Computation Center's IBM 7094 and 360 to: (1) formulate and "debug" a computational sequence embracing a number of simple FORTRAN II programs (to be written by the investigators), together with DCS and SSUPAC library routines for the solution of simultaneous equations, linear programming, and regression problems respectively; and (2) conduct a complete run of the computational sequence with hypothetical data. (Willard B. Hansen)

2909-7N015 T Zoology. Animal Energy Requirements Under Environmental Stress. The bioenergetics of two bird species (house sparrow and blue-winged teal) and one species of aquatic isopod are presently being studied. Specifically, the seasonal fluctuations in isopod energy requirements, the relationship between environmental temperature and energy expenditure in isopods and birds, and the relationships between heart rate and breathing rate in birds are being analyzed by regression techniques. Statistical

comparisons will also be made between temperature tolerance limits of house sparrows collected at different times of year and from different locations in North America. These comparisons will involve analyses of variance and covariance and probit analysis. (R. B. Owen)

2910-7N016 Zoology. Bioenergetics of Animals. Several species of vertebrate and invertebrate animals are being studied to determine their energy requirements under various environmental conditions. Of special interest is determining the minimum levels of energy expenditure necessary for existence and how these levels are affected by environmental temperature. Regression analyses will be used to determine this relationship as well as the effect of temperature on total energy metabolism. Analyses of variance will be used to analyze the changes in different lipid components of the animals with change in environmental temperature. (Jerrold H. Zar)

2911-7N017 Agricultural Engineering. Optimizing Hydrostatic Transmission Systems. The research problem will involve optimizing an engine-hydrostatic for maximum efficiency. Transmission pump and motor data will be gathered from other sources and performance curves derived empirically from the data using least squares methods. The engine-transmission system will be synthesized from the components and overall efficiency calculated by the computer. Varying two of the three control variables independently, the optimal control conditions for maximum efficiency can be determined for the range of desired system outputs. (F. G. Kostrub)

2912-7N018 T Theoretical and Applied Mechanics. Parametric Response of an Elastic Column with Rotary Inertia and Shear Effects. Parametric response belongs to the theory of the dynamic stability of elastic systems which is related to those problems in the theory of oscillations and the stability of elastic systems. Dynamic stability of elastic systems is defined as the study of oscillations induced by a parametric excitation. Parametric oscillations of an elastic system are oscillations occurring due to the periodic change of those properties which remain constant during free oscillations. The elastic system itself changes periodically. The basic reason for this work is to investigate the effect that rotary inertia and shear have on the elastic column as compared to that column which does not include these effects, the Beliaev column problem. To best

illustrate the influence of these effects, several problems will be examined, starting with the linear problem of the Rayleigh beam and advancing to the nonlinear problem which considers the interaction of forced and parametrically excited oscillations. The solution that is of interest is determining the domains of instability, if such exist, for the various problems. A Fourier series solution will be used in the linear problems and a Galerkin method will be used in the nonlinear problem. (James M. Kennedy)

2913-7N020 T Psychology. Personality and Evaluation of Appropriateness of Role Behavior. The purpose of this research is to investigate the relationships of some personality variables to the evaluation of the appropriateness of role behavior. The revised California F Scale and the revised Budner's Scale of Intolerance-Tolerance of Ambiguity were used to measure the personality variables, i.e., authoritarianism and intolerance of ambiguity, and the Role Differential Questionnaire was adopted to assess the opinions on appropriateness of role behavior. 228 university students were given the three instruments. The obtained data will be analyzed to test several hypotheses concerning the relationships between the two personality variables and the appropriateness of role behavior. To analyze the data, three 30x30 correlational matrices will first be computed from three 3420x30 row data matrices. The correlational matrices will then be factor-analyzed by the principal-factor method and for each obtained factor matrix a rotated matrix will be derived by the varimax method. The final rotated factor matrices will then be used to compute the factor-score matrices. The main hypotheses of the research will be tested by calculating Pearson's product-moment correlation coefficients between the role factor scores and the personality scores. All the above computational steps will be done by the computer. (Kuo Shu Yang)

2914-7N021 State Water Survey. 360 System Orientation. This project will be one to help the State Water Survey users becoming familiar with the 360 System. To that end, they will run many various jobs. (Robert Sinclair)

2915-7N022 State Water Survey. Hydrometeorological Studies of Precipitation. Various analyses of precipitation data will be made in conjunction with hydrometeorological research pertaining to hydrology and weather modification. This will involve frequency analyses, regression analyses, and numerous types of statistical testing on data grouped by storm, month, season, and year, and relating precipitation characteristics to various meteorological parameters. (Robert Sinclair)

2916-7N023 T Chemistry and Chemical Engineering. Natural Convection in Horizontal Tube. The effect of heating a fluid in a horizontal pipe is being studied. A computer program has been developed to solve the finite difference representations of the continuity, momentum and energy equations and the results of the computer solution is compared with experimental measurements. (David P. Siegwarth)

2917-7N025 Veterinary Physiology and Pharmacology. Radioisotope Analysis in Feeds. The radionuclide content of animal feedstuffs is measured using a 5" x 4" NaI (Tl) crystal detector. The detector output is fed to a 400-channel pluse-height analyzer. The analyzer readout is by means of punched paper tape. Information on paper tapes is transferred to IBM cards with the aid of the ILLIAC II computer. In feedstuffs, mixtures of 4 to 6 radionuclides are encountered, and a quantitative analysis of individual nuclides in the mixtures is desired. Known quantities of the individual nuclides are assayed in the same counting geometry as the feedstuffs to produce "library" tapes. The IBM 7094 generates a least squares fit between known library spectra and an unknown mixture spectrum, giving the fraction of each library radionuclide present in the unknown. (A. R. Twardock)

2918-7N027 State Geological Survey. Exchange Area Oil Pool Study. A trend surface analysis of various subsurface geological data obtained from electric logs will be made in an area in Marion County, Illinois. (Dave Stenvenson)

2919-7N028 State Geological Survey. Havana Area Groundwater Flow. A three dimensional, non-homogeneous, isotropic model of the Havana Lowlands in Illinois is used to determine steady state ground-water flow in this area. The method used employs trend surface analysis along with solution of finite difference equations by iterative techniques. (Paul Heigold)

2920-7N029 State Geological Survey. Trend Surface Analysis and Automatic Contouring. An attempt will be made to generate trend surfaces of different order and use them for extrapolation or intrapolation of different geological data. By comparing different surfaces for the same set of data the proper residual will be produced. It is also planned to write a contouring program to plot the data generated in the first part. (M. Heidari)

2921-7N030 State Geological Survey. Illinois Base Map Projections. The Illinois base map projection system at the Illinois State Geological Survey will present geologic information in graphic form. The system uses a Lambert Conformal Conic Projection (standard parallels 33° and 45°), and the x-y coordinate unit interval is measured in feet. The data bank includes section corner coordinates of all civil townships in Illinois and county or state boundaries. The stored coordinates are developed by digitizing 7.5-minute and 15-minute topographic maps and by converting these machine digits to the Lambert Conformal Conic Projection. This data bank is used for drawing base maps and for the calculation of coordinate positions from legally described locations. (Paul Dumontelle)

2922-7N031 State Geological Survey. New Albany Electric Log Parameters. The New Albany Shale Group is a body of black shale of late Devonian and early Mississippian age 50 to 300 feet thick, found throughout central and southern Illinois at depths ranging from near the surface to more than 5,000 feet. Its uncorrected electrical conductivity and its spontaneous potential (static charge developed in that part of a mud-filled drill hole opposite the formation) are shown on the electric logs of numerous oil wells and tests for gas-storage reservoirs. A pilot study of these properties in 17 southwestern Illinois counties will attempt to reduce the tedious computation of correction factors and produce maps of polynomic trend surfaces showing the geographic variation. Comparison and analysis of such maps for the stratigraphic subdivisions of the group will allow isolation of trends unique

to an individual unit from trends shared by the entire group. The former represent variation in the conditions of deposition of the individual unit whereas the latter are related to post-depositional conditions such as depth of burial, elevated temperature, and chemical environment. (David Swann)

2923-7N033 T Botany. Absorption of Light by a Spherical Shell. Consider a spherical shell with radii R and r (R>r), filled with an isotropic, non-refracting and light absorbing medium, having an extinction γ (base e) per unit length. A beam of light which enters the outer sphere at a polar angle enters the inner sphere at a polar angle θ'. A measure of the depression of the absorbance in a suspension is the flattening coefficient Q_A, defined as the quotient of the optical density of the suspension over that of the solution. In the case of a spherical shell, the flattening coefficient may be expressed as

$$Q_A = \frac{3}{2\theta} \cdot \frac{1 - \bar{T}_p}{a_p}$$

where $\bar{T}$ (a_p), θ and a_p are defined as before. A computer program was written to evaluate a family of curves of $\bar{T}$ (τ) was found by τ as a constant and varying a from .0 to 2.50 by steps of .01. Different curves were evaluated for different values of τ by varying the ratio of R/r from 1.05 to 3.00 by steps of .05. The corresponding family of curves of Q_A were evaluated at the corresponding values of R/r. (Govindjee)

2924-7N034 Nuclear Engineering. Motion and Interaction of Ions and Electrons in a Cylindrical Fusor. The program studies the motion of ions injected into a long cylinder, the creation of secondary electrons, ionization of background gas, charge exchange reactions, electric field and potential, and particle densities. The program will solve for the potential and electric field at each point using the method of image charges, and compute the new position and velocity of each particle every nanosecond of simulated time. Ionization and charge exchange reactions will be handled in a statistical manner, using random numbers selection for decisions. The program will handle up to 2000 electrons and ions with a simulated reaction time of microsecond. The output will be used to plot the electron and ion densities as a function of time and position. This

program is very important in that it simulates the Fusor (a plasma device) and will furnish the best theoretical results to go with actual experiments in the laboratory. (Dan Weidenfeld)

2925-7N035 Agricultural Engineering. Farm Machinery Selection. The problem is one of finding the least cost equipment system for given farm inputs. Data cards are prepared for each farm instance and fed into the computer with a FORTRAN program developed at the University of Illinois. Power levels, tillage practices, row spacings, harvesting systems and other farm practices are to be evaluated and fundamental relationships developed. The computation involves the solution of many algebraic equations and an iterative computation for the optimum system. (D. R. Hunt)

2926-7N036 T Economics. An Econometric Model for Over-Populated Developing Countries. The present study purports to develop a model of economic growth presumably applicable to the over-populated developing countries and to test the validity of the model through a critical analysis of the economic structure of Korea, the working of her economy, the development strategies taken and results obtained, in terms of quantified data of economic variables. Both the aggregative econometric and disaggregative micro-model will be built. The macro-model will include a system of equations, such as national expenditure equations (which will consist of the consumption function, investment function, international trade function, tax function, etc.), income formation equations, technical progress function, supply equation for agriculture produce, price formation equation, and so on. Each equation to be set up represents the behavior of some elements of economic system. The coefficients of these equations will be estimated simultaneously through the computer, and the estimated coefficients will be evaluated for their significance according to economic theory. (Yoon Keun Song)

2927-7N039 Champaign Public Schools. Unit 4 In-Service Training. The purpose of the research is to provide teachers with objective data relative to teacher and student classroom verbal behavior. The data will be obtained by trained observers gathering the data through the use of a verbal interaction analysis system. As the data is fed back to the teachers, new techniques and approaches will be tried by the teachers with the intent of bringing the intended behavior and actual behavior into greater congruence. Such change in teacher and student behaviors will then be measured by comparing the matrices of the varying observations. (Anderson)

2928-7N040 T City Planning. Impacts of Buildings and Use on Motor Vehicle Accidents. The problem is to examine the impact of the physical forms (buildings, street furniture, etc.) generated by the land use activity surrounding urban roads as elements of motor vehicle accident causation. It is hypothesized that the physical forms surrounding urban roadways distract the driver from his primary task of vehicular operation. Such distraction may be due to the efforts of the driver, consciously or subconsciously, to perceive the surrounding forms while moving along the roadway. Several physical and psychological variables, in terms of driver distraction hypotheses will be tested in built-up areas surrounding arterial streets in the city of Chicago. The areas to be chosen will exhibit a distribution of low to high, mid-block, head-on, rear-end or fixed object accident rates involving only drivers from out of the Chicago Metropolitan Area. The variables to be tested, as building setback, the width of the driver's visual field and the textural and proportional relationships between adjacent buildings will be compared through a multiple correlation procedure in an attempt to determine if and how a physical form-accident correlation exists. Preliminary to any correlation procedure will be the selection of a stratified sample of locations yielding a normal distribution of accidents. In selecting the sample, all physical and traffic flow elements of the locations will be held constant. The only elements which will be allowed to vary will be the independent variable, physical forms, and its dependent variable, accidents. The expected correlation should yield the variables directly related to driver distraction. From a study of these variables, quantitative design limits as well as qualitative design principles will be enumerated in an effort to stipulate some guidelines for the design of forms surrounding urban roads directly related to the preceptive needs of the motor vehicle users. (Leslie S. Pollock)

2929-7N041 City Planning. The Impact of Transportation Systems on Urban Land Value. The purpose of this project is to examine the development of an urban growth model for the micro-region and for the region as a whole. The primary variables to be used in this study are various transportation systems and the price of urban and agricultural land. Generally regression analysis will be used to examine the hypothesis and will include linear, exponential and power tests. (Jerrold Voss)

2930-7N042 City Planning. Metropolitan Models Sequence. The purpose of this ADP project is to "computerize" an illustrative analytical system for comprehensive metropolitan plan-making. The system in question is being developed by the senior investigator to illustrate the role of mathematical techniques and automatic data processing in urban planning practice. It will be produced as a training manual for classroom use in UP 376 (Planning Analysis) and in continuing professional education courses. When completed, it will comprise an integrated sequence of planning agency tasks, a set of computer programs for performing these tasks and a small pool of input data which represent conditions in a hypothetical medium-sized metropolitan region. The tasks will provide examples of such basic analytical procedures as estimation, prediction, prescription and calibration. They will entail a variety of mathematical models ranging in complexity from simple empirical presumptions to input-output, linear programming, and regression-based relationships. (Willard Hansen)

2931-7N043 City Planning. Departmental Training. The proposed use of this time is to permit the Department to utilize the IBM 360 for instructional purposes and for graduate research. (Jerrold Voss)

2932-7N044 T City Planning. Linear Programming Application to Urban Planning. Graduate thesis problem in urban planning dealing with applications of linear programming. The model makes use of the linear programming algorithm to allocate recreational open space within a regional setting. (James McLaughlin)

2933-7N045 T Psychology. Factor Analysis of the Auditory Evoked Cortical Response. This problem is an investigation of the relation between a certain type of human brain-wave evoked by sound (the auditory evoked cortical response) and the human subject's verbal estimate of the loudness of the sound. The brain-waves will be broken down into components using factor analysis, and each component will be separately compared with the verbal estimates of loudness. Over half a millian pieces of data are involved. (Howard Rothman)

2934-7N046 Chemistry and Chemical Engineering. Calculation of Electronic Spectra. The calculation of electronic spectra is achieved by diagonalizing the hamiltonian matrix for the ground and excited states. Rotational constants are input. The program takes account of the proper selection rules, and then calculates the correct frequences of transition. Each line is then given a shape, and the total intensity is summed. The spectrum is plotted and compared with the experimental spectrum. When correct rotational constants are chosen the two will match. (Lombardi)

2935-7N047 Finance. An Analysis of Portfolio Risk and Other Related Variables on the Rate of Return of Common Stock Portfolios of Life Insurance Companies and Property and Liability Companies. This will be an empirical study of the common stock portfolios of thirty-five life insurance companies and thirty-five property and liability companies for the period of 1957 to 1966. The study will be divided into two parts, first an analysis of common stock portfolios of life insurance companies, and second an analysis of the equity portfolios of property and liability companies.

The first objective of the study is to determine the rate of return on common stock portfolios of thirty-five life insurance companies for the period of 1957 to 1966. A second objective is to utilize regression analysis to examine the relationship between rate of return on common stock portfolio and the following variables: (1) portfolio risk (variability of annual returns, i.e., standard deviation of annual returns); (2) percent of total portfolio held in common stock; (3) net common stock purchases as a percent of total investment purchases; (4) composite rate of return on bond, real estate and mortgage portfolios; (5) percent of total business in term and group insurance; (6) surplus as a percent of total liabilities; (7) total asset size; and (8) type of company - stock or mutual.

This part of the study will follow the same methodology employed in the life insurance study. The variables in the regression analysis will be the same as those above except that number five (5) will be replaced by a variable measuring the reserve policy of the insurer. (James A. Gentry)

2936-7N049 T Business Education. Related Variables of the Firm's Stock of Human Capital. Basically, this research problem is founded on the contention that the accumulation of human capital stock for a specific firm or industry in analogous to the accumulation of the stock of physical capital for a specific firm or industry. The author has developed a model in which he has identified certain independent variables which are considered significant to the employment level of the stock of human capital of a specific firm or industry. This expression is summarized in the following equation:

$$X_{1t} = a + bX_{2t-1} + dO_{t-1} + eO_{t+1} + fX_{1t-1} + gw_{1t} + hw_{1t-1} + iw_{1t+1} + jw_{st} + kw_{st+1} + lr_{ct} + mr_{ct+1} + ntc_{t} + otc_{t+1} + pi_{t} + qi_{t+1} + rp_{t} + sp_{t+1} + t\,s_{t} + us_{t-1} + vs_{t+1} \quad .$$

In other words, the present stock of human capital, X_{it}, or production workers employed by a firm or industry is dependent on some constant, a; some parameter of the stock of physical capital employed during the previous production planning period (a planning period represents eight quarters or two years), bx_{2t-1}; some parameter of the production output for the previous planning period, dO_{t-1}; some parameter of the production output for the coming planning period, eO_{t+1}; some parameter of the stock of human capital employed during the previous planning period fx_{1t-1}; some parameter of the present wage rate of production workers, gw_{1t}; some parameter of the wage rate of production workers for the previous planning period, hw_{1t-1}; some parameter of the wage rate of human capital for the coming planning period, iw_{t+1}; some parameter of the present wage rate for substitutes to production workers (overtime costs), jw_{st}; some parameter of the wage rates of substitutes to production workers during the coming planning period, kw_{st+1}; some parameter

of the present cost of complements to production workers, lr_{ct}; some parameter of the cost of complements to production workers for the coming production planning period, mr_{ct+1}; some parameter of the present total operating costs, ntc_t; some parameter of the total operating cost for the coming production planning period, otc_{t+1}; some parameter of the present rate of interest for a comparable investment risk, pi_t; some parameter of the rate of interest for a comparable risk during the coming production planning period, qi_{t+1}; some parameter of the present price level of the production output, rp_t; some parameter of the present rate of production by production workers, $t\ s_t$; some parameter of the rate of production by production workers during the previous period, us_{t-1}; and some parameter of the rate of production by production workers during the coming production planning period, vs_{t+1}. The author intends to test the significance of these relationships empirically through the application of a stepwise regression routine with a one- or two-stage least square analysis. Also, this test includes the Durbin-Watson test of correlation. The data included in this analysis has been collected from published documents of the Bureau of Labor Statistics, Board of Governors of the Federal Reserve Board, the Federal Trade Commission, and the Securities and Eschange Commission. All data are relative to quarterly observations for the tobacco industry during the period 1947 through 1966. (John R. Swanda, Jr.)

2937-7N050 T Theoretical and Applied Mechanics. Fatigue Crack Propagation Studies. Catastrophic failures have paralleled the use of high strength materials for aerospace applications. These failures are mainly caused by environmentally induced slow crack growth which results in the eventual rupture of these highly stressed components. By employing fracture mechanics techniques, many investigators have studied the effect of statically applied loads on these materials in various environments. Presently, fatigue crack propagation is being studied in air and other gaseous environments. Recently developed analytical tools have now made it attractive to investigate combinations of fatigue loadings and aqueous environmental conditcns. This investigation will provide a better understanding of the stress corrosion mechanism and will result in useful information for designers confronted with the slow growth problem. (J. P. Gallagher)

2938-7N051 WPGU Radio Station. Log and Accounting Program. This time is requested for rewriting existing programs in PL/1. These programs handle the printing of the Program Logs and the tally of commercial accounts. (Dale A. Eltoft)

2939-7N052 Children's Research Center. Learning Time Estimation Via Motor Response. In a previous problem (Ellis, M. J., Schmidt, R. A., and Wade, M. G., Proprioception Variables as Determinants of Lapsed Time Estimation. Ergonomics, in Press), movement was identified as a variable that improved the learning of a two second interval. This has led to the present study that attempts to identify which of the informational aspects of the feedback from a simple motor response mediates the estimation of time. By a factorial between subjects design, information for position, velocity and acceleration will be varied in the execution of the movement of a cursor along a trackway by 7th and 8th grade children. The influence of these variables on the learning or performance of the task will be disentangled by means of a transfer experiment. The factorial study will involve a simple two-way mixed analysis of variance, and the learning versus performance study will involve the use of a planned comparisons analysis. The number of experimental groups will be 12 with 15 subjects per group. Computer programs prepared by Statistical Service Unit (Research) will be used to test hypotheses concerning the effects of the independent variables. (M. J. Ellis)

2940-7N053 T Chemistry and Chemical Engineering. Dynamics of a Tubular Reactor with Recycle. The dynamics of a tubular chemical reactor with material and thermal recycle are to be investigated theoretically and experimentally. The simplified mathematical model of the reactor system requires the solution of a boundary value problem. A numerical integration routine with a variable step size and a Newton-Raphson iteration scheme are being used to solve the equations. The recycle tubular reactor will be simulated experimentally using an adiabatic batch reactor. The batch reactor data and the computer will be used to predict the behavior of the tubular reactor and to obtain a mathematical expression for the rate of reaction. The data obtained from the operation of a recycle tubular reactor will be analyzed and used to evaluate the mathematical model and the batch reactor simulation. (R. B. Root)

2941-7N054 Nuclear Engineering. Nuclear Engineering 490 Course Development. The study is concerned with the possible use of nuclear radiation to neutralize space charge effects in a thermionic diode. A program has been developed to calculate internal diode voltage for input values of net current density. The program uses standard techniques to solve coupled algebraic equations. A parameter study will be conducted to determine the effect of varying the diode plasma parameters on the volt-ampere characteristics. The results will be used as part of the material to be presented in NE 490 Direct Energy Conversion. (Theron D. Carlson)

2942-7N055 Electrical Engineering. VRO 120 Stress Analysis. The Structural Engineering Systems Solver is to be utilized by the investigator to check prelinimary design specifications for a proposed 120 foot radio telescope, to be constructed by the University of Illinois at the Vermilion River Observatory. The data for programming has been computed and tabulated from the architect's design drawings and the Structural Engineering Systems Solver results will be used to determine the degree to which the design meets the required specifications. (A. H. Schriefer)

2943-7N056 Home Economics. Champaign County Food Purchasing Study. As a study which contributes to the North Central Regional Project, Food Purchases and Utilization by Families with Preschool Children, the Department of Home Economics is investigating food purchasing practices of families with preschool children in Champaign County. A representative sample of approximately 300 households has been drawn. Data are being collected by personal interviews using a revised instrument based upon an earlier pilot study which includes buying practices and use of specific food commodities. An attempt is also being made to determine what effect the presence of preschool children may have upon family food purchasing decisions. The computer will be used to obtain the following: (a) frequency distribution and cross tabulation tables; (b) the sample error; and (c) tests of statistical significance. (Glenna H. Lamkin)

2944-7N057 Chemistry and Chemical Engineering. Transistor Matching. The computer will be used to match transistors for use as input pairs of operational amplifiers. Matching is by base emitter voltage, current gain and the change of those quantities with temperature. Data were obtained by manual testing of individual transistors on a special test arrangement. (W. L. Allred)

2945-7N058 T Aeronautical and Astronautical Engineering. Aerodynamics of Finite Oscillating Wings. The problem will be concerned with the solution of the integral equations formulation of the aerodynamics of finite wings under arbitrary periodic deformations. The primary area of consideration will be ornithopter wing motion in incompressible flow. The mathematical solution of the integral equation will be by either series expansion or successive approximation. (A. G. Bennett, Jr.)

2946-7N060 Electrical Engineering. Optical Resonator Calculations. The semi-infinite wave-guide problem has been solved by Wiener-Hopf techniques and the kernal expressed in factorized form as an infinite product. This infinite product solution will be compared in rate of convergence and accuracy to several approximate solutions in integral form. (L. M. Peterson)

2947-7N061 T Chemistry and Chemical Engineering. Microwave Spectroscopy. Problems in Microwave Spectroscopy involve the calculation of some molecular parameters from measurements of the rotational absorption spectra of molecules in the gas phase. Certain electronic and nuclear interactions with the molecular rotation are evidenced by shifts in or splittings of absorption lines for specific rotational transitions. Analysis of these shifts or splittings by quantum mechanical methods gives information about the nature and magnitude of the various interactions within a molecule. (W. H. Flygare)

2948-7N062 Theoretical and Applied Mechanics. Familiarization with IBM 360. The TAM Department was granted five hours free of charge so that the TAM staff could become acquainted with the IBM 360. Four hours of this time has already been allocated to individual staff members for their personal research. The most efficient use of the remaining hour would be to have the TAM graduate students use a few minutes each if they desire. A notice will be distributed to all TAM graduate students notifying them that they may use a few minutes time on the IBM 360 for the purpose of getting acquainted with the new system. (John Ford)

2949-7N063 T Theoretical and Applied Mechanics. Plastic Anisotropy. An experimental and analytical investigation into plastic anisotropy of metals is to be made. Initially, the computer will be used to process the raw data and then to fit curves of an elliptic form to the experimental data points. It is propcsed to use 7094 library routine LSQ3 which uses a least squares method to accomplish a curve fit. Finally, routine SETPLT will be used to plot the curves. (Robert Frederking)

2950-7N065 State of Illinois Department of Mental Health. Systems Technology Applied to Community Mental Health. The application of systems engineering to the administrative management and evaluation of a community mental health program is proposed. Mental illness is treated as life impairment whose etiology resides predominantly in the socio-cultural environment of high-risk population subgroups, and in the availability and delivery of services. Mental health is conceptualized as a health and welfare social system and the existing state and county health and welfare agencies are subjected to a systems analysis. Heuristic modeling by mathematical and computer simulation language programs is completed for the health and welfare network in given communities. Mathematical methods include matrix algebra with adoption of Leontief's input-output models, and recursive equations using linear regression models and auto regressive and moving average models. Perturbation analyses are performed with simultaneous parametric values to test hypotheses on improved methods of service and dollar value. Systems design studies are completed and simulated for developing meaningful and feasible hypotheses. Project significance is seen in demonstrating the capability of applying systems and computer science for more effective program planning, delivery of services, and community organization activities. (Wm. F. Eicker)

2951-7N067 Chemistry and Chemical Engineering. Curve Fitting of Experimental Pressure Data. Attempts will be made to find an analytical equation for the pressure distribution around a cylinder in laminar flow. It is hoped that the pressure gradient around a cylinder can be obtained. The data to be used in this work were taken from the literature. The pressure distribution will be fitted with an odd power series in the angle from the rear stagnation point; the pressure gradient, with an even power series in the angle. These two results will then be compared to determine which method

will yield the best description of the system. Analytical expressions for the pressure distribution will ultimately be used to obtain the theoretical stress distribution in the wake behind a cylinder using boundary layer theory. This theoretical distribution will then be compared to experimental distributions to determine the validity of boundary layer theory in the wake. (J. P. Matula)

2952-7N068 Home Economics. Hatch Home Economics Study on Use of Pest Controls. A Study of Illinois Consumers' Reactions to Use of Pest Controls on Agricultural Products--The overall objective is to obtain insight concerning the Illinois consumers' knowledge of attitudes toward, acceptance of, and demand for agricultural products subjected to varying degrees and alternative methods of pest control. Specific objectives of the project are as follows. For a representative sample of consumers: 1) to study the relationship between knowledge of and attitudes toward the use of agricultural products subjected to pest control; 2) to study not only the attitudes but also the strength of these attitudes toward the use of agricultural products subjected to pest control; 3) to study the relationship between knowledge of and acceptance of the use of agricultural products subjected to pest control; 4) to study the relationship between attitudes toward and acceptance of the use of agricultural products subjected to pest control; and 5) to study the relationship between attitudes toward and demand for agricultural products subjected to pest control. The method of analysis of data will be multiple linear regression. In one instance the dependent variables will be knowledge and the independent variables will be the socio-economic characteristics of the households surveyed. In another instance, the dependent variable will be total attitude and the independent variables will be the socio-economic characteristics of the households and total knowledge. The sample consists of 704 usable family records. The Federal Government is very concerned with determining people's attitudes toward agricultural products subjected to pest control. It is anticipated that the information from this study will be used to determine educational programs and legislative action. (Dunsing)

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2960-7N082 Agricultural Engineering. Farm Structures. Solutions to Wooden Column Problems are to be solved by iteration. The CalComp plotter is also to be used in data analysis and parameter comparisons. (Don Jones)

2961-7N083 T Electrical Engineering. Inverse Scattering. An algorithm to calculate the spacial current distribution which gives rise to a given far field pattern was developed and a few special cases are to be tried to determine the accuracy required of the far field pattern to obtain the source distribution to a specified accuracy. Using a recursion formula, a series expansion valid outside a sphere containing all the sources is obtained from the given far field. In a region in which the series expansion is valid, a set of Huygen's sources which gives rise to the same field pattern is obtained. Using the Huygen's sources as the only sources, a field expansion is obtained. The point at which the electric field goes to zero is taken as a point on the surface of the original current distribution. Using a different region in which the series is valid, another set of Huygen's sources is found and proceeding in the same manner, another point of the surface is obtained. Continuing the process, the required source distribution is recovered. (William A. Imbriale)

2962-7N084 Agronomy. Simulation of an Exponential Regression Model. The exponential regression model, $Y=XAK^{X}$, has been used to represent the non-linear relationship between the yield of corn per unit area, Y, and the number of plants per unit area, X. The parameters A and K have biological significance and vary with genotype and environment. The present problem is concerned with comparing several methods of computing estimates of A and K, comparing the effects of introducing random sampling errors on a per plant basis versus a per unit area basis on the estimates of A and K, and finally comparing the effects of various ranges of values of X on the estimates of A and K. In addition, the effects of assigning various "true" population

values to the parameters on the above comparisons will be studied. A computer program to simulate suitable experiments and perform the necessary statistical analyses of the generated data has been written and checked out. This program will be utilized in this present study to gain insight on the question of "how much precision can be expected in estimation of parameters from future field experiments?" (Carmer)

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area of feasible decisions by smaller firms and thus reduce the opportunity for undesirable decisions. The value of this reduction must be compared with its cost. A number of cost functions will be developed and compared with alternative ways of reducing the feasible decision area by information development. Formulas to be used will include linear and non-linear relationships, statistical description and Bayesian analyses, and an indeterminate number of cost functions of indeterminate level. Data were derived from government publications and direct interviews. (Norton M. Bedford)

2973-7N098 City Planning. Springfield Economic Forecast. The purpose of this project is to project employment by various categories for Springfield and Sangamon County to the year 1990. In addition to the Springfield/Sangamon County forecast, similar forecasts will be made of the United States, Mid-West Region, and the State of Illinois. These forecasts will be used in a step-down procedure in order to predict Springfield/Sangamon County employment. The basic mathematical technique used is regression analysis both linear and exponential. The data used in this analysis was obtained from the U. S. Bureau of Labor Statistics. (Jerrold Voss)

2974-7N099 Chemistry and Chemical Engineering. Hydrodynamic Stability in Reacting Fluid Layers. The hydrodynamic stability of a horizontal layer of fluid with reaction at the lower surface will be studied. A numerical solution of the Navier-Stokes equations with the Boussinesq appriximation, combined with the heat conduction equation and a mass balance for each diffusing species, for the quiescent steady state will be found using linear stability theory. The convective steady states may be found by solving numerically the time-independent, nonlinear equations, and stability of these steady states may also be determined using linear theory. Of particular interest in this investigation will be the effect of buoyancy forces, here arising from temperature variation across the fluid layer, on the nature of steady states of the system. (R. C. Buchanan)

2975-7N100 Materials Research Laboratory. Electro-Absorption. We want to convert the program used in 7094 to FORTRAN IV used in 360. (Paul Handler)

2976-7N101 T Materials Research Laboratory. Data Reduction. Data obtained from three phase transition experiments in parametric form will be reduced by elimination of the parameter to standard form. These data will be compared to theoretical Ising model predictions by using least squares curve fitting techniques. Because the functions the data is being fit to are non-linear, the least squares procedure yields a set of non-linear algebraic equations for the undetermined constants. Newton's method for a system of non-linear equations will be used in an iterative calculation to obtain the solution. The computer will be used extensively to obtain machine drawn plots of the experimental results. (H. A. Blackstead)

2977-7N103 State Water Survey. Stream Flow and Time-of-Travel Study. Stream flow and time-of-travel are two important factors affecting the waste assimilative capacity of a stream or river. The purpose of the study is to estimate the stream flow and the time-of-travel of a volume of water between two points of a stream.

1. Estimation of the flow at each mile-point of a drainage basin.
    a. Data: Drainage area and flow at mile-points from information published by the United States Geological Survey.
    b. Compute the incremental drainage area added per mile: Increased drainage area divided by the length of the main stem.
    c. Compute the incremental flow added per square mile: Increased flow divided by the net drainage area.
    d. Compute the correct flows at mile-points by the incremental drainage area and flow.
2. Estimation of the volume of water between two mile-points.
    a. Compute each cross-section area A at a certain surface water level in a reach and sum then, get $\sum A$ from detailed river cross-sections available from the United States Corps of Engineers.
    b. Compute average cross-section area $\overline{A}$ and the length between points L.
    c. Compute volume of water: $Vol = \overline{A} \times L$

The time-of-travel t is determined by the volume of water in the reach divided by the average flow $\overline{Q}$ in the reach. $t = Vol/\overline{Q}$ (Shunndar Lin)

2978-7N104 T Chemistry and Chemical Engineering. Flow Around a Circular Cylinder. A numerical solution of the time-dependent equations of motion for two dimensional flow of a viscous fluid around a circular cylinder has been obtained for Reynolds number of 40. The results of this solution are given in terms of the stream function and vorticity distribution in the flow field (mesh points). The computer will be used for plotting the streamlines and equi-vorticity lines from the results of the above solution. (Jaime Santos Son)

2979-7D002 Student Counseling Service. Programmed vs. Face-to-Face Psychotherapy. The study is designed to compare programmed and face-to-face psychotherapy in regard to the treatment of excessive anxiety on examinations. The present stage of the research involves extensive investigation into the nature of examination anxiety and some preliminary studies of its manifestations in special situations. Data has been collected and is being collected on a small sample of students where therapy is being conducted dealing with test anxiety, and on two other small samples where test anxeity is being evaluated under conditions of high and low stress. Also, large samples of students are to be studied for the purpose of studying the relationships of test anxiety to many other variables. These include the relation of examination anxiety to interpersonal attraction, a comparison of high and low anxious students in high and low stress situations and a number of inter-correlational studies relating test anxiety to such variables as intellectual ability, scholastic achievement, and various personal or emotional factors. Many of the studies will be correlational including some factor analysis. Analysis of variance and possibly analysis of covariance will also be used. (Thomas N. Ewing)

2980-7D003 T Electrical Engineering. Power Transmission Through Dielectric. The problem consists of calculating electromagnetic power transmission through a lossless dielectric plate with parallel sides. The incident electric field is parallel polarized so that a Brewster angle exists. Equations for the reflection and transmission coefficients used are the standard ones found in any text on electromagnetic theory. The computer is used to calculate the multiple internal reflections that constitute the power transmission. After the power trnasmission has been calculated for different angles of incidence between the dielectric and the electric field, a curve of power transmitted versus angle is graphed. (John Rejeris)

2981-7D004 T Materials Research Laboratory. Solution of Gorkov Integral Equation. It is desired to solve a linear homogeneous integral equation in a finite range, obtaining the unknown function and an eigenvalue. The unknown function is expanded in a power series; the resulting integrals can be evaluated analytically. In t h i s manner, the problem is reduced to solving n homogeneous algebraic equations in n unknowns; the eigenvalue is obtained by demanding that the determinant of these equations vanish. It is then a simple matter to determine the coefficients in the power series. (Allan Jacobs)

2982-7D005 Agronomy. Chemical Changes in Soils. The objectives of this study were to investigate the extraction characteristics of the aluminum-bound fraction of phosphorus in different soils. Experiments were designed to study the rate of extraction of phosphorus from soils along with factors affecting the extraction. Soil constituents which are active in the conversion of added fertilizer to the aluminum-bound fraction have also been studied by measuring flouride-extractable aluminum in soils. With the use of correlation and regression analyses the relationship between phosphorus and aluminum can be found. In addition, analysis of variance will be used to study the effect of several variables such as extraction time, solution ratio, reagent concentration, and reagent pH on the amount of phosphorus extracted. The presence or absence of interactions between different factors studied will further aid the standardization of methods of phosphorus extraction. The aluminum-bound phosphorus has been shown to be an important fraction in supplying phosphorus to plants and a detailed study of this fraction can lead to a better planning of soil-plant-fertilizer programs and evaluation of phosphorus fertility of the soil. (Kurtz)

2983-7D006 T Civil Engineering. Interaction Diagram for R. C. Columns. High strength reinforcing bars with and without splices are used in reinforced concrete beams and columns. These types of reinforcing bars do not have flat top stress-strain characteristics. Consequently such reinforcement may reduce or increase the strength of a reinforced concrete section compared to what is predicted on the assumption of flat top stress-strain curve for steel. This research deals with the investigation of the effects of stress-strain curve of steel on the strength of a reinforced concrete section. The computer will be used to make calculations for load-moment relationship of reinforced concrete sections. The numerical procedure involves a trial-error solution

2978-7N104 T Chemistry and Chemical Engineering. Flow Around a Circular Cylinder. A numerical solution of the time-dependent equations of motion for two dimensional flow of a viscous fluid around a circular cylinder has been obtained for Reynolds number of 40. The results of this solution are given in terms of the stream function and vorticity distribution in the flow field (mesh points). The computer will be used for plotting the streamlines and equi-vorticity lines from the results of the above solution. (Jaime Santos Son)

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2981-7D004 T Materials Research Laboratory. Solution of Gorkov Integral Equation. It is desired to solve a linear homogeneous integral equation in a finite range, obtaining the unknown function and an eigenvalue. The unknown function is expanded in a power series; the resulting integrals can be evaluated analytically. In t h i s manner, the problem is reduced to solving n homogeneous algebraic equations in n unknowns; the eigenvalue is obtained by demanding that the determinant of these equations vanish. It is then a simple matter to determine the coefficients in the power series. (Allan Jacobs)

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2988-7D013 T Chemistry and Chemical Engineering. Optimal Control of a Stirred Tank Reactor. The optimal control of a continuous stirred tank reactor will be studied using several different numerical techniques. The mathematical formulation of the optimal control problem involves finding the control parameters which will extremize some integral function over time. In the case of a stirred tank reactor the control parameters are coolant flow rate and reactant feed rate. These parameters may be subject to constraints. Pontryagin's maximum principle which is an extension of variational calculus is frequently used to solve this type of problem. Pontryagin's maximum principle leads to a solution by trial and error of a two-point boundary value problem. Dynamic programming can also be used to solve the optimal control problem. This method requires a large computer storage capacity. Linear programming can also be used but requires linearization of the non-linear model of the stirred tank reactor. A steepest descent method which is an extension of Lyapunov's Direct Method for stability analysis will lead to an approximate solution of the problem. (F. C. Stone)

2989-7D014 Psychology. Effects of Attitude on Learning. Use of free time to educate 7094 users on 360. (Malpass)

2990-7D015 Nuclear Engineering. Lie Series Analysis of the Coupled Heat Conduction and Point Reactor Kinetics Equations. An important effect in reactor dynamics calculations is that of temperature feedback. To study this effect in more detail, a coupled set of differential equations are derived from the time dependent heat conduction equation and the point kinetics equations. The problem is defined for a cylindrical fuel rod. The radial dependence is eliminated by a Hankel Transform and a system of first order linear differential equations are obtained. The numerical solutions for this system are then generated from Lie Series Analysis Techniques. (Peddicord)

2991-7D016 Psychology. Effects of Attitude on Learning. Objective: to demonstrate the conditions under which prior attitude effects the learning and recall of attitudinal materials such that congenial materials are learned and recalled better than uncongenial materials, and to investigate the nature of the process by which effects occur. Mathematical methods: Statistical techniques including analysis of variance, analysis of covariance, correlation and scaling analysis of summated rating (Likert) scales will be used. Data collection: Data will be collected by questionnaires, in experimental sessions,

and from field observations. Computer results will be used in preparing materials for experimental sessions, for subject selection and assignment, and as inferential aids in data interpretation. (R. S. Malpass)

2992-7D017 T Sociology. Danville Foster Home Sponsors: A Role Analysis. The problem, "Danville Foster Home Sponsors: A Role Analysis," is comprised of data obtained from private interviews, each lasting over two hours. The data from the 24 interviews was collected by the prime user in a period of two weeks in June of 1967. It is anticipated that the computer will be used to summate various scores, run the appropriate measures of significance and perform certain measures of association. More specifically, SSUPAC programming will be employed to run "t" tests, rank order correlations and to summate the various scores that operationalized this study's concepts. The computer's results will be used to determine whether the differences found between various groups of sponsors are statistically significant and to determine the amount of explained variance provided by the various categories. (Lauren Seiler)

2993-7D018 Sociology. Integration of Control Agencies in Japan. Survey data from approximately 700 officials from nine social control agencies in Tokyo and 250 clients of these agencies will be analyzed using standard SSUPAC programs, primarily X^2 tests of significance, gamma coefficients, and analysis of variance. Data were obtained via standardized questionnaires which pertain to attitudes toward problem juveniles and organizational response to them, reported inter-organizational interaction, and personal-social data. Results will be used to test hypotheses concerning the integration of a system of social control agencies. There are approximately 250 data items coded for each official. (John Clark)

2994-7D019 Engineering Administration. Predictive Model for Engineering College Resource Requirements. This project will provide a model by which we can predict the required material and manpower resources for the various departments of the College of Engineering. This model will examine historical data to obtain the relationships of controllable variables (budget, staff size, size and number of research projects undertaken) to "projectable" variables (enrollment, building space, etc.). The historic data will be updated at each run. (Etnyre)

2995-7D020 Engineering Administration. Effect of Federal Spending on Engineering Programs. This project will examine the historic relationship between the amount of federal funding alloted to various engineering departments and the research activities supported by the departments. A sensitivity analysis will be developed and applied to possible projections of federal support to determine the levels of research which can be justified in the departments. (Etnyre)

2996-7D021 Chicago Circle Sociology. Census Tape Duplication. Computer time is needed so that Service Programming can develop and test a program to copy and condense seven reels of census data onto one reel. A request for this job has already been submitted to Mr. Tom Allen of Service Programming. Mr. William Klecka of the Data Repository, Survey Research Laboratory, will be responsible for supplying the original tapes and technical information. (Richard J. McKinlay)

2997-7D023 T Chemistry and Chemical Engineering. Extended Hückel Calculations for E and C Numbers. The strength of an acid or base has been shown to be characterized by two numbers, E and C. The heat of interaction between a given acid and base is then given by $E_A x E_B + C_A x C_B$, where the subscript A refers to the number for the acid and B to the number for the base. The physical significance of these E and C numbers is unknown and the purpose of the present project is to uncover their physical significance by applying extended Hückel molecular orbital calculations to several acids and bases and their combinations. The extended Hückel program uses linear combinations of exponential functions to describe the atomic orbitals. The matrix of overlaps between the exponential functions is first calculated and then combined to give the matrix of overlaps between the atomic orbitals. Next the Hamiltonian matrix is constructed using empirically determined values for the diagonal elements and a rule for calculating off-diagonal elements which uses the corresponding overlap element from the overlap matrix and the two corresponding diagonal elements of the Hamiltonian matrix. The Hamiltonian matrix is then diagonalized to give the eigenvectors which give the coefficients of the atomic orbitals in the molecular orbitals. This is the result of the calculation. This information can then be used to calculate various properties of the acid or base such as polarizability which may correspond to E or C numbers. If such properties are found, it would make possible much better predictions of acid-base properties. (T. E. Needham)

2998-7D024 Botany. Molecular Weight Determinations. The molecular weight of a protein may be determined through the proper evaluation of data obtained from an analytical ultracentrifuge sedimentation equilibrium experiment. In such an experiment, a macro-molecular substance, dissolved in an appropriate buffer, is sedimented until an equilibrium concentration gradient is established. The state of sedimentation equilibrium may be taken as the state at which equilibrium is attained between the transport of a solute due to sedimentation and the reverse transport from diffusion. By employing the Rayleigh (interference) optical system of the analytical ultracentrifuge, concentrations at various points in an analytical cell can be determined with respect to the distance from the center of rotation. The logarithms of the concentrations at various points are then plotted versus the squares of these points. The slope of a line connecting the points generated by such a plot gives the molecular weight of the substance. A program using a least squares routine from the computer facility library has been constructed to calculate the molecular weight distribution from the Rayleigh optics data. (M. E. Reichmann)

2999-7D025 Office of Instructional Resources. Test Analysis. The computer will be used to score and analyze many different types of objective tests. The analysis to be performed will consist of bi-serial correlations, factor analysis, factor rotation, and test reliability. There will undoubtedly be other statistical procedures applied to the data which cannot be foreseen at this time. The major objective of this study is to devise generalized procedures for analyzing objective tests, and thus increase the usefulness of objective tests.
(Richard E. Spencer)

3000-7D027 State Water Survey. Electromagnetic Scattering from Rain. Raindrop size spectra have been obtained at seven different climatic regions around the world. These data are to be analyzed to determine the electromagnetic back scattering and attenuation cross-sections for a number of different wavelengths. A part of the calculations of the scattering coefficients will be performed at the Lincoln Laboratories of the Massachusetts Institute of Technology. (E. A. Mueller)

3001-7D028 T Advertising. The function of Empathy in the Adoption of Farm Innovations. Through the application of a communication model based on social psychological theory, this study will attempt to clarify the processes of communication by accounting for the various factors that intervene between the time of exposure of an individial to a medium of communication and the actual adoption of a new farm practice. Specifically, it hopes to determine the relationship between the degree of empathic ability and rate of adoption of new farm practices and the relationship between emapthic ability and exposure to mass media. Mathematical methods used will be analysis of variance using the "F" test and multiple correlation. The findings are expected to determine whether there is any significant difference between various categories of farmers with respect to empathic ability, mass media exposure, cosmopoliteness and self-image. Data were obtained through questionnaires administered to farmers in Indiana. Computer results will be used for a Ph.D. dissertation and for possible publication. (Cleofe Martinez)

3002-7D029 T Psychology. Attitude Survey of Job Satisfaction. This study is designed to determine the interactive effects of leader characteristics and situational variables on satisfaction with the leader and with the co-workers. Data was obtained from retail store employees through questionnaires. The analysis of the data will involve correlations, principal axis factor analysis and analysis of variance. The computer results will provide the statistical analysis necessary for substantiation of the findings. (H. P. Dachler)

3003-7D030 T Computer Science. Numerical Problems in Fourier Analysis. Fourier Series is a very important tool both in theoretical and numerical analysis. Tukey and Cooley's algorithm happens to be a very efficient computing method to calculate the Fourier coefficients. Since error is always an important factor in numerical field, this research is intended to make some kinds of error analysis about Tukey and Cooley's method. It has been proved that if the errors involved in the function values used in Fourier analysis are normally distributed the errors of the calculated Fourier coefficients are also normally distributed. Some computations will be made to test whether the error of the coefficients calculated by Tukey and Cooley's method will follow the same law or not. (Chin-Kuei Wen)

3004-7D031 T Education. Comparisons of Leadership Styles with Normal and EMH Children. The main hypothesis for this study is that the degree of shift of leadership style from democratic to authoritarian will be far greater in low Minnesota Teacher Attitude scorers than in high scorers when the population is changed from normal to retarded. The aims of the dissertation were to: (1) determine if college students who score high in the Minnesota Teacher Attitude Inventory will tend to perceive and enact their leadership roles in a democratic manner, while those who score low will tend to assume authoritarian styles of leadership; (2) identify and develop techniques and instruments useful in determining authoritarian and democratic leadership styles; and (3) compare the actual behavior of recreation leaders in settings for normal children with the actual behavior of recreational leaders in similar settings for educable mentally handicapped children to determine if actual leadership styles change with changes in the population (normal to retarded; retarded to normal). Multiple correlations will be computed using variables of the attitude score and the characteristics of the counselors. Rank order correlation between the attitude score and the counselor perception questionnaire (using number of democratic responses as a basis for ranking) will be determined. In addition, analysis of variance will be employed to compare leadership styles as observed between groups (A and B) and between sessions for high and low scores. This statistical data will be obtained from the 7094 computer, and will provide the basis for acceptance or rejection of the dissertation's main hypothesis. The subjects for this project consisted of students enrolled in Recreation 174, Camp Counseling, in the College of Physical Education at the University of Illinois. The thirty subjects were obliged to participate in six consecutive Saturday morning day camp sessions. At these sessions 25 "normal" and 25 educable mentally handicapped children were enrolled to attend the camp sessions. (Susan Shuster)

3005-7D032 Physics. Regge Pole Fits to High Energy Data. Various experimental data on the high energy scattering and reactions of elementary particles are to be fit, using the method of least squares, by the formulas from the Regge pole model for these processes. The success or failure of these fits will help to determine the validity of the Regge pole model. (R. A. Miller)

3006-7D034 T Sociology. Demographic Aspects of Careers in Academic Librarianship. This study deals with a national sample (N = 2438) of librarians employed in colleges and universities in the U. S. A mailed questionnaire was used to collect data concerning the education, job experience, salary, work activity, and personal characteristics of academic librarians. The objective of the study is, first of all, to characterize the types of careers which are typical in academic librarianship. Secondly, the project will attempt to define particular characteristics (such as education, job experience, demographic characteristics, and so forth) which are associated with various types of careers in librarianship. Frequency counting procedures will be used to isolate various types of career experience in academic librarianship. Correlation analysis and factor analysis will be used to identify particular characteristics (or groups of characteristics) associated with various career patterns. Computer results will be essential for defining the major variable being studied (career patterns in academic librarianship) and for analyzing variables associated with these various experiences. (James Grimm)

3007-7D035 T Sociology. Social Mobility and Kinship Relations. A study will be done to determine the effects of social mobility on kinship relations. The concern of the study is with the effects of occupational and status mobility on the laterality of kinship relations. Also of interest is the effect of social mobility on a number of subjective feelings of respondents toward their kin. Data was obtained through interviews with approximately 300 husbands and wives in the Champaign-Urbana community. The sample was obtained with assistance of seven nursery schools in Champaign-Urbana. Information was obtained on approximately 6,000 relatives of the 300 respondents. This number makes data processing by computer necessary. Frequency counting, one-way and two-way; significance testing such as t-tests and Chi-square; and more sophisticated techniques such as multiple discriminant analysis and factor analysis will be used. These results will be used for a Ph.D. dissertation. (C. Mindel)

3008-7D036 T Advertising. Analysis of Selected Aspects of the J. L. Hudson Company Teenage Promotional Approaches. The focus of this study will be on Detroit teenager attitudes toward the J. L. Hudson Company. Emphasis will concern teenager attitudes of Hudson's advertising, sales personnel, and selected promotional events directed toward them. The problem is multiple: (1) teenager attitudes toward Hudson's teen clothing departments in general;

(2) teen attitudes toward Hudson's teenage advertising; (3) teen awareness and participation in selected promotional events; and (4) teen media habits. Hypothesis: The J. L. Hudson Company teenage shoppers (1) have favorable attitudes toward Hudson's teen clothing departments and sales personnel; (2) have favorable impressions of Hudson's advertising to teenagers; and (3) have high awareness and participation in the promotional events surveyed. Methodology consists of 700 mailed questionnaires to Detroit area teenagers. At the present time, 54.9% (374) have been returned. Expected return is 60% (420 questionnaires). The questionnaire is concerned with teenage media habits, general reaction to various characteristics of a semantic differential in regard to Hudson's teenage advertising, and scale reaction rankings. In part, the statistical analysis to be performed will consist of: (1) frequency counting and conversion of absolute numbers into percentage distribution; and (2) conversion of scale judgments into mean values by various groupings. In turn, certain comparisons will be made to determine the statistical significance of observations and will be handled by the "t"-test or analysis of variance. (Leonard Zimmerman)

3009-7D037 Geography. Determination of Percentages of Days Per Month and Year Within Comfort Zone Categories. The research problem is to determine the average percentage of days per month and per year which fall into a particular category, based on 15 years of data. This will be accomplished by a three-step process: (1) determination of the maximum effective temperature based on temperature and relative humidity information for each day of the year for 15 years at four stations; (2) determination of the category into which each of these effective temperatures fit, based on a set of comfort categories; and (3) determination of the average percentage of days per month and per year which fit into each category for each station based on 15 years of data. The data obtained were already on cards and represent weather information obtained by standard equipment at four first order stations in Illinois. The cards are the property of the State Water Survey. The results will be used to construct a new classification of climates based on effective temperature and comfort zones. (Warren Fish)

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11.1 Class Problem Specifications

During the fourth quarter of 1967, 57 problem specifications were submitted to cover all assigned problems in the following courses.

J796-7ø001	Aeronautical and Astronautical Engineering 216.
J797-7ø002	Civil Engineering 201.
J798-7ø003	Mechanical Engineering 293.
J799-7ø004	Electrical Engineering 355.
J800-7ø009	Electrical Engineering 389.
J801-7ø011	University High School 100.
J802-7ø019	Physics 341.
J803-7ø020	Physics 342.
J804-7ø025	Electrical Engineering 349.
J805-7ø026	Electrical Engineering 251.
J806-7ø027	Agricultural Engineering 357.
J807-7ø029	Electrical Engineering 297.
J808-7ø030	Industrial Administration 401.
J809-7ø031	Theoretical and Applied Mechanics 425.
J810-7ø032	Computer Science 999.

J811-7Ø038	Psychology 352.
J812-7Ø039	Electrical Engineering 497.
J813-7Ø049	Geology 493.
J814-7Ø061	Electrical Engineering 497.
J815-7Ø062	Electrical Engineering 322.
J816-7Ø071	Architecture 494.
J817-7Ø077	Mechanical Engineering 995.
J818-7Ø092	Mechanical Engineering 342.
J819-7Ø109	Electrical Engineering 423.
J820-7Ø110	Nuclear Engineering 458.
J821-7N014	Geology 455.
J822-7N019	Theoretical and Applied Mechanics 293.
J823-7N024	Mechanical Engineering 438.
J824-7N026	Mathematics 392, Illinois College, Jacksonville, Illinois
J825-7N032	Psychology 469.
J826-7N037	Mining, Metallurgy, and Petroleum Engineering 497.
J827-7N038	Music 244.
J828-7N048	General Engineering 232.

J829-7N059	Electrical Engineering 322.
J830-7N064	Electrical Engineering 272.
J831-7N066	Political Science 440.
J832-7N069	Industrial Engineering 286.
J833-7N072	Agricultural Engineering 146.
J834-7N073	Political Science 328.
J835-7N075	Political Science 451.
J836-7N076	Physics 383.
J837-7N081	Astronomy 433.
J838-7N091	Electrical Engineering 498.
J839-7N092	Geology 493.
J840-7N095	Civil Engineering 201.
J841-7N102	Theoretical and Applied Mechanics 235.
J842-7D001	Educational Psychology 411.
J843-7D009	German 461.
J844-7D010	Electrical Engineering 475.
J845-7D022	Electrical Engineering 324.
J846-7D026	Computer Science 457.

J847-7D033	Accountancy 108.
J848-7D039	Mathematics 123.
J849-7D040	Education 240.
J850-7D046	Mechanical Engineering 214.
J851-7D047	Mechanical Engineering 264.
J852-7D048	Mechanical Engineering 263.

12. GENERAL DEPARTMENT INFORMATION

12.1 Personnel

The number of people associated with the Department in various capacities is given in the following table:

	Full-time	Part-time	Full-time Equivalent
Faculty	19	4	21.39
Visiting Faculty	3	1	3.67
Research Associates	1	0	1.0
Graduate Research Assistants	8	96	1.0
Graduate Teaching Assistants	0	2	.83
Professional Personnel	22	3	23.75
Administrative and Clerical	23	1	24.5
Nonacademic Personnel (Monthly)	69	1	69.5
Nonacademic Personnel (Hourly)	1	89	35.2
TOTAL	146	197	232.94

The Department Advisory Committee consists of Professor J. R. Pasta, Head of the Department; Professor J. N. Snyder, Associate Head of the Department; Professors L. D. Fosdick, H. G. Friedman, C. W. Gear, D. B. Gillies, D. J. Kuck, B. H. McCormick, S. Muroga, T. A. Murrell, J. Nievergelt, R. S. Northcote, J. R. Phillips, W. J. Poppelbaum, S. R. Ray, J. E. Robertson, P. E. Saylor, and D. L. Slotnick.

12.2 Bibliography

During the fourth quarter, the following publications were issued by the Laboratory.

File Numbers

(1) Lopeman, Harold E., "Information on the DEC 360 Communications Control Unit," File No. 738, October 11, 1967.

(2) Richardson, F. K., "A User's Description of the Computer Aided Programming System (CAPS) Programs on the DEC 338," File No. 739, December 19, 1967.

Specification Numbers

(1) Carter, Clifford E., "Specifications for an On-Line Plotter System for an I.B.M. System/360 Computer," File No. 550-107, October 6, 1967.

(2) Serio, F. P., "Procurement Specifications for Wirings of Circuit Rack Assemblies," File No. 550-106, October 2, 1967.

(3) Snell, J. L., "Interactive Array Wiring (Condensed)," File No. 550-108, November 2, 1967.

(4) Snell, J. L., "Interactive Array Wiring," File No. 550-109, November 2, 1967.

Reports

(1) Cancro, R. and Slotnick, D., "Some Thoughts on Displays," Report No. 251, November 12, 1967.

(2) Jackson, E. A., Pasta, J. R., and Water, J. T., "Thermal Conductivity of One-Dimensional Lattices," Report No. 250, October 1967.

(3) Robertson, J. E., "The Correspondence Between Methods of Digital Division and Multiplier Recoding Procedures," Report No. 252, December 21, 1967.

12.3 Colloquia

"Automation of Chemical Experiments," by Dr. Y. Okaya, New York State University, Albany, New York, October 2, 1967.

"Monte Carlo Methods," by Professor Lloyd D. Fosdick, Department of Computer Science, University of Illinois, Urbana, Illinois, October 16, 1967.

"A Parallel Machine for Signal Processing," by Dr. J. Githens, Bell Laboratories, Whippany, New Jersey, October 23, 1967.

"Computer Applications to the Railroad Industry," by Mr. E. Wrathal, IBM Corporation, White Plains, New York, October 30, 1967.

"The Short Happy Life of LISP2," by Dr. Paul Abrahams, New York University, Courant Institute of Mathematical Sciences, New York, New York, November 13, 1967.

"CSMP/360 - A Program for the Simulation of the Dynamic Behavior of Physical Systems," by Mr. H. N. Tyson, IBM Corporation, Glendale, California, November 20, 1967.

"Developments in Integer Programming," by Professor M. L. Balinski, City College of New York, New York City, New York, December 4, 1967.

"Threshold Logic in 1967," by Dr. R. O. Winder, RCA Laboratories, Princeton, New Jersey, December 18, 1967.

12.4 Drafting

During the fourth quarter, a total of 379 drawings were processed by both drafting sections:

	General	Pattern Recognition
Large Drawings	38	80
Medium Drawings	42	0
Small Drawings	116	14
Layouts	3	0
Report Drawings	0	8
Changes	20	16
Miscellaneous	12	30
TOTAL	231	148

(M. Goebel and J. Otten)

12.5 Shops' Production

Job orders processed and completed during the fourth quarter of 1967 are as follows:

	AEC 1018	AEC 1469	Other
Machine Shop	51	42	47
Electronics Shop	35	30	8
Etch Shop	26	33	20
Layout Shop	26	24	17

Wiring of 533 standard printed circuit boards during this period, accounted for 5,319 diodes and 8.098 transistors.

(F. P. Serio)